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The Factory Report

Mr. A. W. Garrett, H.M. Chief Inspector of Factories, in his Report covering 1941 has unfortunately once again to call attention to the increased number of both fatal and non-fatal accidents. Deaths from accidents have risen from 944 in 1938 to 1,646 in 1941, while non-fatal accidents rose from 179,159 to 269,652 during these years. Obviously, Britain's labour force has grown at a bewildering rate, but so too have industrial accidents, actually a matter of 50 per cent. As to the accident rate per 1,000, the rises shown are also seriously high, but there is some relief to be found in the fact that comparing 1938 with 1941, then one man in 25 would be liable to accident in the earlier year compared with one in 20 last year. The corresponding figures for women, boys and girls are: 1 in 105, as against 1 in 56; 1 in 23, as against 1 in 19, and 1 in 70, as against 1 in 56. Accidents to women employed in the foundry and kindred industries have risen from 1,010 in 1938 to 3,140 in 1941. Mr. Garrett, in stressing the regrettably large number of accidents to women which are ascribed to the catching in machinery of loose hair and loose clothes, believes that the wearing of caps as a preventative measure is second only to the proper fencing of machinery. He likes the poster, showing how the Russian girl worker deals with her hair, as a piece of propaganda. We would prefer one making reference to the number of face-washings per week, as compared with the frequency of hair-shampooings, as both uncovered hair and face are equally exposed to the accumulation of dirt in factories. The established factory girl is particularly sensitive as to the cleanliness of her head! We have learnt to look in these annual reports for hints of future legislation, but this time we can only detect a laudable desire to marry A.R.P. requirements with existing factory regulations. The requirements of the Factories Act for safety, says the Report, " must be accepted without question." A statement which will interest most foundry executives is that the Safety Officer will never be really effective unless he is given the status at least equal to that of a responsible departmental manager. We feel genuinely sorry for a foreman who has to carry out the instructions of his manager, the personnel manager, the safety first officer, the works costs accountant, and, maybe, others. It is especially distressing as the major practical contributions to all the subjects covered by these specialists have originally been made by men of the enlightened foreman type. We are at least pleased that Mr. Garrett says, in effect, that the safety officer must be endowed with full executive authority, for it will work better in general than when they act in an advisory capacity. The foreman will at least know where he stands. If such a measure can materially reduce the 50,000,000 man-hours lost per month through industrial accidents then it will be thoroughly worth while. Yet this question of dual or multiple control will ever remain controversial. Success will be associated with cases where a sympathetic and enthusiastic outlook on the subject is shared by all concerned. The Chief Inspector has much to say about ventilation, and his remarks seem to us to be addressed more to his colleagues in other industries than to Mr. Ernest Bevan and the general public. We, too, have not failed to notice how the provision of blast walls, blacked-out windows and other A.R.P. activities have deleteriously affected otherwise well-ventilated workshops. We were pleased to see the way the subject of lighting has been dealt with. A laudable desire to save fuel is often but penny wisdom. If inadequate lighting produces scrap components, the fuel and power

(*Continued overleaf.*)

Contents

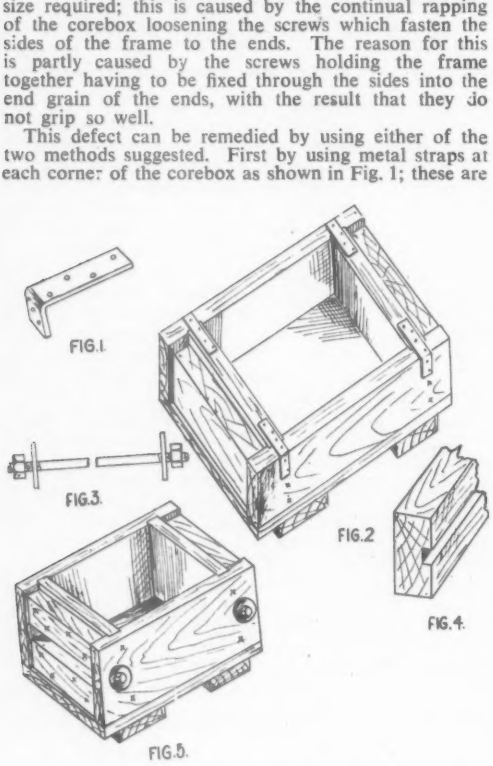
The Factory Report, 157.—Strengthening Coreboxes, 158.—U.S. Standards for Enamelled Utensils, 158.—The Use of X-rays in the Foundry, 159.—Aluminium Production in U.S., 170.—Utilising Atmospheric Pressure in Making Steel Castings, 171.—Fuels for Melting Furnaces in Light-Alloy Foundries, 176.—Metallurgy of Induction Heating, 177.—Durability of Moulding Sands, 178.—Export Licensing Extensions, 179.—News in Brief, 179.—Death of Dr. Percy Longmuir, 180.—Control of Factory Premises, 180.—Obituary, 180.—United Steel Companies, Limited, 180.—Company News, 182.—New Companies, 182.—New Patents, 182.—Raw Material Markets, 184.

STRENGTHENING COREBOXES

By CHECKER.

When framed coreboxes have been in constant use for a considerable time the sides sometimes open, especially at the top, making the cores larger than the size required; this is caused by the continual rapping of the corebox loosening the screws which fasten the sides of the frame to the ends. The reason for this is partly caused by the screws holding the frame together having to be fixed through the sides into the end grain of the ends, with the result that they do not grip so well.

This defect can be remedied by using either of the two methods suggested. First by using metal straps at each corner of the corebox as shown in Fig. 1; these are



made out of ¼ in. mild steel, and bent to go over the sides, screwholes are drilled and countersunk ready for fixing in position. It is advisable to cut a recess in the frame the size of the straps so that they are level with the top, to allow the coremaker to strickle freely over the face of the core. The dimensions of the straps may vary according to the size of the coreboxes, but for a corebox 2 ft. square, ¼ in. by 1 in. section mild steel, 6 in. on the top, with 2 in. bent round the sides, has been satisfactory. Fig. 2 shows the straps in position.

The second method is to bolt the frame together by using ½ in. dia. bar tapped at each end for a nut and using a large washer, as shown in Fig. 3, the washer being used to get a grip on a bigger surface. The holes for the bolts are drilled in the sides so that they will be as near to the ends as possible. The end battens must have a recess cut out for clearance as shown in Fig. 4, or the battens can be put on in two pieces, one each side of the bolt, as shown in Fig. 5, which also shows a corebox with the bolts in position, the ends of which should be knocked over to stop the nuts becoming loose.

U.S. STANDARDS FOR ENAMELLED UTENSILS

The National Bureau of Standards, Washington, D.C., has established labelling standards for enamelled utensils which became effective on September 30. The new standards cover requirements for enamelled utensils for cooking, household, food storage and hospital use, including specific limitations on impact resistance, acid resistance, resistance to thermal shock, requirements and tolerances for capacity, dimensions and thickness of base metals. The requirements were decided upon with the co-operation of manufacturers, wholesalers and the Bureau of Standards in an effort to standardise the quality of these products.

THE FACTORY REPORT

(Concluded from previous page.)

necessary for their replacement will quickly neutralise any gain accruing from parsimonious lighting. Quite often, good housekeeping, directed towards the keeping of reflectors clean and lamps in good condition, is a proper approach to fuel economy.

Included in the Report is a section on health by Mr. J. C. Bridge. Herein it is pleasing to learn that the general health of the industrial worker remains at its pre-war level. Silicosis is not mentioned, but the increase of pulmonary diseases is commented upon. Recently it was stated that there were some 15,000 cases existing in early stages in the country, and any one of these might conceivably become first a sandblaster and later a compensation case! There is also a report on "Hours of Employment," which, in truth, resolves itself into a study of the permutations and combinations of working hours and off days so as to produce a satisfactory-to-all working week. The final Report is by Miss D. Johnson on "Canteens." She is to be complimented on presenting a well-written and essentially readable story of the enormous growth of these still modern industrial amenities. The advantages and difficulties encountered are well set out, and the note as to the payment of canteen workers is timely, as the transfer of members of the canteen staffs to the production side has often been widespread, owing to the better rates of remuneration obtainable.

THE USE OF X-RAYS IN THE FOUNDRY*

By W. MONTGOMERY, †

An account of many interesting practical applications of radiography to the examination of ferrous and non-ferrous castings

During recent years there has been an ever-increasing number of Papers read before various technical and scientific societies on subjects relating to the application of X-rays in industry. Mostly, they have been concerned with technique, theory, and application from the viewpoint of the industrial radiologist. It is intended that this Paper will interest foundrymen and more particularly those who control moulders or who exercise technical control over foundry practice. All reference, therefore, to the wider field of industrial radiology, including the routine examination of welded steel vessels and structures will be omitted.

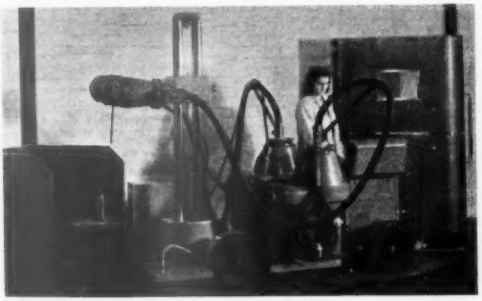


FIG. 1.—SIEMENS-SCHUCKERT X-RAY EQUIPMENT, RATED AT 250 KV. AND USED FOR THE EXAMINATION OF CASTINGS UP TO A METAL THICKNESS OF 3½ IN. OF STEEL OR IRON.

It is interesting to note that Röntgen, in his pioneer work, realised the value of the "Röntgen" rays in the examination of the gross structure of metals, although it was the medical faculty, and not the metallurgical fraternity, which gave the new tool its initial flying start.

Does the average foundryman realise what a valuable tool this can be? Too often it is regarded by craftsmen as a mysterious scientist's eye, which brings to light unimportant flaws in castings, which would be far better left shrouded in the limbo of the invisible, well below the metal surface, and beyond the ken of an ardent inspector! No idea could be more mistaken. The proper conception of works' radiographic control is that, with sympathetic technique and interpretation, hitherto unsuspected flaws may be located, and, moulding or melting practice having been reviewed, finally eliminated.

Simple Explanation of Theory

Everyone may not be potential owners, users, or operators of an X-ray equipment, but it is assumed that some day all engineers and foundrymen will

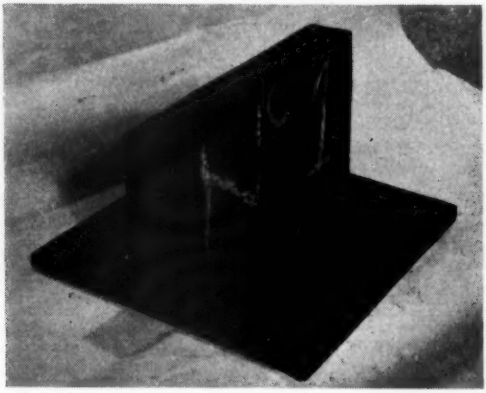


FIG. 2.—SHAPE OF TEST-PIECE.

be asked to handle, inspect, or offer an opinion on a radiograph, and for that reason it is deemed advisable to include in this Paper a simple, though probably sufficient, explanation of the underlying principles in the "gross structure" examination of metals.

X-rays are a form of radiant energy analogous to light rays and they obey the same laws of reflection, refraction and diffraction. The intrinsic difference is in their respective wave-lengths. The wave-length of light is about 5,000 Angstrom

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Use of X-Rays in the Foundry

units at the centre of the visible spectrum, while X-rays vary in wave-length between 500 and 1A. This significant difference in wave-length between visible light rays and X-rays holds the explanation of the latter's ability to penetrate material opaque to ordinary light. It will be readily realised that any radiation having a wave-length approximately 1,000 times less than that of ordinary light will slip past molecules of matter in much the same way as light darts through the interstices of a Venetian blind.

How X-rays are Produced

Essentially, this type of radiation is produced when the atoms of a heavy metal such as tungsten are bombarded with electrons. These electrons are units of negative electricity which rotate round the metallic nucleus in orbits as the planets round the solar system. In practice, free electrons are produced by heating to incandescence a filament at the cathode of a very highly-evacuated glass tube. These electrons are caused, by the application of high voltage, to impinge at very high velocities on the target or anode of the tube. The interference in the atomic arrangement of the metal composing the target, due to the impinging electrons, produces the radiation known as X-rays.

The wave-length of the rays decreases, and conversely their penetrative power increases, with increase in the exciting voltage. The potentials necessary for penetrating up to 5 in. of steel are of the order of 90,000 to 300,000 volts. These high potentials are obtained by stepping up the ordinary A.C. mains voltage by means of a transformer. The alternating current is made unidirectional by mechanical rectification or, as is more usual in modern equipments, by the use of thermionic valves. Of the total input of energy at the target of an X-ray tube, only a small proportion is converted to X-radiation—the remainder being dissipated as heat. This, as will be appreciated, necessitates the provision in the plant of some system of cooling to remove unwanted heat from the target material. If the tungsten anode became overheated, it would start radiating electrons, the current would flow in the opposite direction and lead to the rapid breakdown of the tube. Most tubes are water or oil cooled. For industrial purposes they are enclosed in a lead holder or container with a small light-metal "window" to allow the passage of the rays in a controlled beam in one direction only at the will of the operator. Fig. 1 shows a typical equipment by Siemens-Schuckert, rated at 250 kV and used for the examination of castings up to a metal thickness of 3½ in. of steel or iron. It will be noted that the complete unit is self-contained, and, while it is ordinarily housed in a special test-room, it could, on occasion, be transported to any situation in the foundry where a primary A.C. source of current is available.

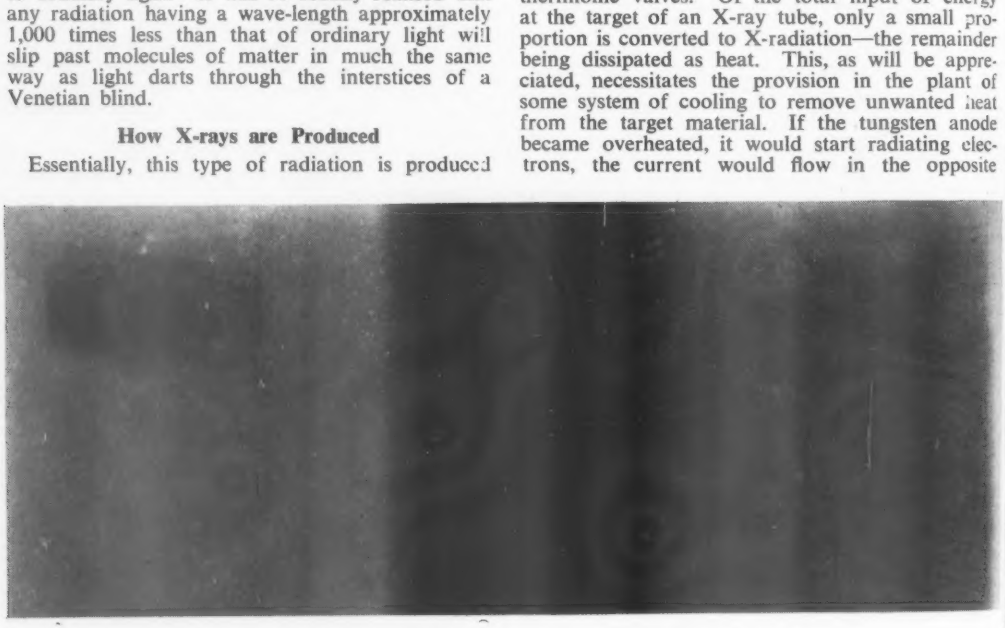


FIG. 3.—SECTION OF RADIOGRAPH OF COLD-POURED TEST-PIECE.

Use of X-Rays in the Foundry

The fact that X-rays are actinic to photographic emulsions in the same way as visible light, makes their industrial application possible. Ordinary practice indicates that the film or plate be placed behind and as near the object as possible. The beam of rays, which for practical purposes is presumed to emanate from a point source, penetrates the object and the proportion of the original rays which emerges from the side remote from the tube affects the photographic emulsion on the film, which is, naturally, encased in a light-tight container. Thus, it will be understood, a point to point difference in density will be obtained on the film, after developing and fixing the silver salts in the emulsion, corresponding to differences in intensity in the X-ray beam as it emerges after traversing a solid object. Differences in thickness in the object will thus show on the film as variations in density. Similarly, a void such as a gas pocket within the wall thickness of a casting will appear on the X-ray film as a shadow of greater density than the adjoining flawless section of metal. An inclusion of greater opacity to the rays than the surrounding metal will naturally absorb more of the incident rays and show on the film as an area of less density. Flaws equal in magnitude to more than 1 or 2 per cent. of the cross-sectional thickness of the metal under examination are capable of detection.

Application to Castings

Before X-ray examination can become a useful instrument in castings inspection, foundrymen must establish an elastic criterion of acceptance or rejection. By this it is not suggested that a particular casting, having six blowholes instead of a maximum of three, should be rejected, but rather that it should be judged, by competent interpreters, with consideration for the size, type, amount, and position of the inclusions, taking into account the ultimate service which will be required of the finished casting.

The various types of flaws and inclusions which are discernible on a radiograph are shown in the accompanying illustrations. Although professional interpretation is a matter of experience in both radiology and moulding practice, a study of the pictures will allow any foundryman to give, at least, a knowledgeable interpretation to any radiograph. The only flaws likely to be found in castings are:—(1) Blowholes, gas holes and air pockets; (2) inclusions of foreign material, *e.g.*, sand, slag, ladle lining material, oxide, segregations of an insoluble secondary metal or even undissolved chaplets; (3) shrinkage cavities or draws; (4) porosity; (5) cold shuts and mis-runs, and (6) pipes and cracks.

It will be seen that the number of flaws to be found in any one casting is strictly limited but, unfortunately, the variety of forms which each shows on the radiograph is considerable. Happily,

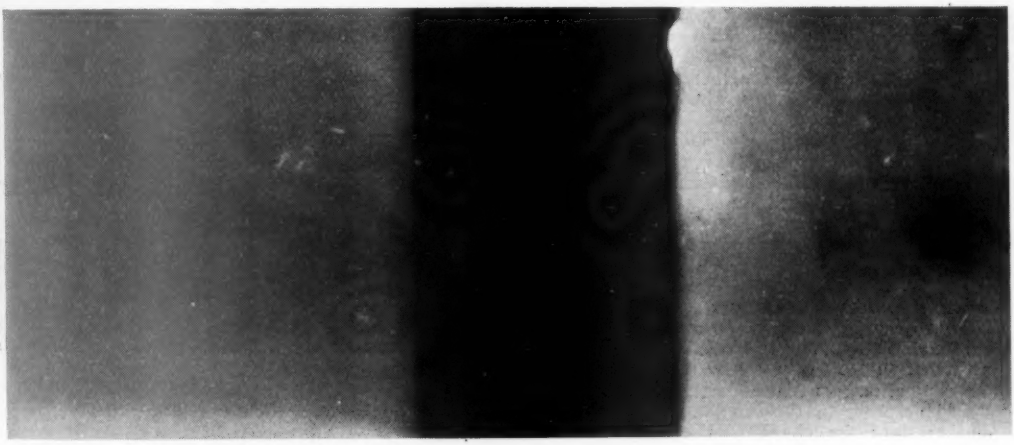


FIG. 4.—SECTION OF RADIOGRAPH OF HOT-POURED TEST-PIECE.

Use of X-Rays In the Foundry

although no two shrinkage cavities display an exactly similar shape or outline, there is a particular disposition of the "shadows" in each case which leads the experienced eye to diagnose each correctly.

Experimental Data

Two synthetic specimens were first prepared. They took the form of T-shaped cast-iron webs, one section of which, in each case, was 2 in., while the base was ½ in. thick. A shrinkage defect or "draw" was certainly to be expected near the changes in section. One piece was cast very hot, while the other was poured with exceedingly sluggish metal. Before closing the moulds, a piece of ladle skimming was inserted in each to represent a state of affairs which could conceivably occur in practice if faulty pouring methods allowed a little dross or slag to enter the mould. In the hot-poured specimen was also included a stud chaplet, while a wet spot was made in the sand on the top part in the hope of inducing "scabbing." The cold-coated stud chaplet inserted. It will be instructive to study the radiographs with particular regard to these conditions.

The shape of the test-piece, together with the position of the thick web, is shown in Fig. 2. Figs. 3 and 4 have been taken with the rays incident to the bases or thin sections, and thus offer a plan view through the castings.

In the cold-poured specimen (Fig. 3) it will be seen that little, if any, fusion has taken place at the chaplet cast-iron interface, and that round gas inclusions are near the chaplet. A small light inclusion near the chaplet indicates that a spot of molten lead has been carried by the primary stream of iron away from the coated chaplet and been trapped in the surrounding metal. The slag inclusion appears as a slightly elongated intense shadow of even outline. All slag inclusions, which incidentally are usually much smaller in normal production castings than is indicated by this deliberate inclusion, are invariably even in outline and often vary in shadow value throughout the image. Occluded gas often takes the form of small clusters of bead-like shadows, as is shown in the radiograph under examination. Steam "blows" from a damp mould often conjoin and the radiographic result is a

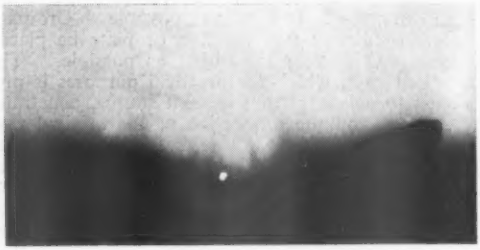


FIG. 5.—SHOWING FEATHERY APPEARANCE OF MAIN "SCABBED" AREA OF CASTING SHOWN IN FIG. 4.

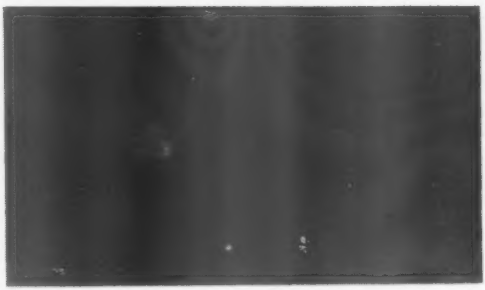


FIG. 6.—CASTING WITH TOP-HAT CHAPLET, SHOWING GAS TRAPPED WITHIN CHAPLET.

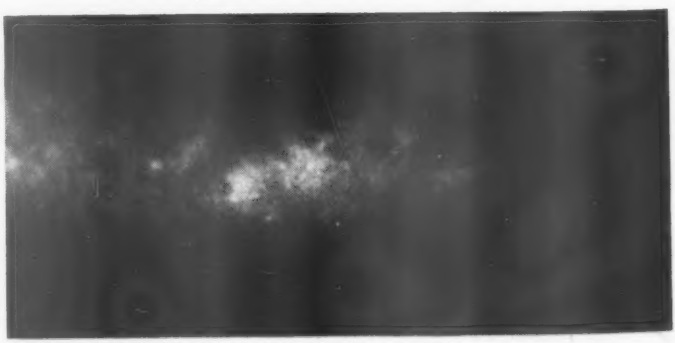


FIG. 7.—TEST CASTING POURED COLD SHOWING SHRINKAGE.

FIG. 9.—SECTION THROUGH DRAW.

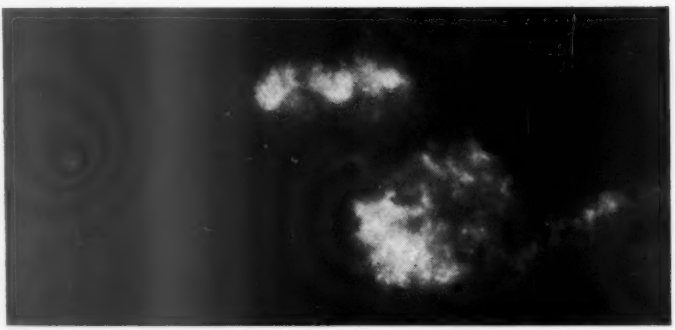


FIG. 8.—TEST CASTING POURED HOT SHOWING SHRINKAGE.

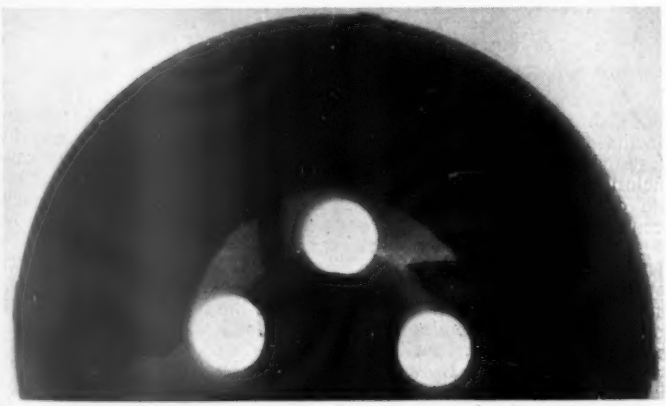


FIG. 10.—SECTION OF RADIOGRAPH SHOWING CRACKS IN CAST-IRON IMPELLER.

gross shadow of even outline somewhat similar to the large slag inclusion discussed before. The essential difference is that gas tends to outcrop towards the upper surface of the mould in a pipe formation, often in the direction of the primary flow of metal in the mould.

Behaviour of Chaplets

In considering Fig. 4, the first noticeable feature is the absence of gaseous indication on the radiograph, going by the criteria established in the previous examination. This, of course, is in consequence of the higher pouring temperature. The chaplet, too, has fused more thoroughly in this case, although it is interesting to note that the ordinary tin coating has not diffused into the surrounding metal; this is shown by the patchy appearance of the chaplet shadow. The feathery areas are mostly sand inclusions.

Fig. 5 shows the feathery appearance of the main "scabbed" area in this same casting. The scab was located at the base of the heavy web. This necessitated projecting the rays through the base of the web at an angle of 45 deg. to the base of the casting, and explains why one side of the resulting radiograph was so dense, while the image at the opposite edge was deliberately produced by the incidence of a wet patch on the mould surface.

It may be interesting to compare the behaviour of the chaplet in Fig. 6 with the previous two. This is a type commonly known in the trade as a "top-hat" chaplet. The radiograph shows that much better contact is obtained between this form and the parent metal, but that gas evolution still takes place.

Figs. 7 and 8 show the radiographic appearances of the shrinkage defects in the two castings. The filamentary form of the shadows is typical of this "draw" formation. When a casting exhibits this scattered void defect, it will

be readily seen, from these pictures, how prone to weeping or leaking under a water pressure test it would be. There is notable difference between the hot- and cold-poured specimens. A section through the draw in the cold-poured casting is photographed in Fig. 9.

An Extra Variable

In a third casting similar in all respects, but one, to the two test castings just discussed, and which was moulded from the same pattern, gated and poured under identical conditions, and made from metal of similar composition and melted under similar conditions, the only outstanding difference was that a brand of machine-cast pig-iron, which formed part of the charges for the other two castings, was omitted. A remarkable difference was observed in the extent of the internal shrinkage, and it is suggested that, at least in this particular case, the inclusion of this brand of pig-iron contributes quite considerably to the tendency for drawing to occur.

Stress-Removal in Impeller Castings

Profit might result from examination of the impeller casting in Fig. 10. Cracks may be seen in the periphery, just at the junctions of the curved spokes with the body of the casting. It was suggested that these castings were flawed before they ever left the foundry, but radiological examination before and after the castings were commissioned soon elucidated the mystery. The indication was that casting stresses bound up in the metal, due to design difficulties, were relieved only by physical fracture after the castings were put into service in sulphuric-acid pumps. On this assumption, the impellers were all given a low-temperature stress-relieving anneal, and no further trouble has been experienced. Fig. 10 is interesting, in that the case history shows how X-rays can vindicate the foundryman on occasion.

A Faulty Pump Casting

Fig. 11 is a picture of a pump where an extremely bad shrinkage cavity shows at the base of a web cast on as a seating. The other round cavity indicates the presence of a steam or gas "blow." The seriousness of the shrinkage defect lay in the fact that all the castings which showed radiographic indications of shrinkage, leaked very badly at this spot. This illustration proves that radiographic examination can, in some cases, pay its way many times over by a very considerable saving in machining costs. As in this instance, alteration to pattern, or in gating methods, may be indicated.

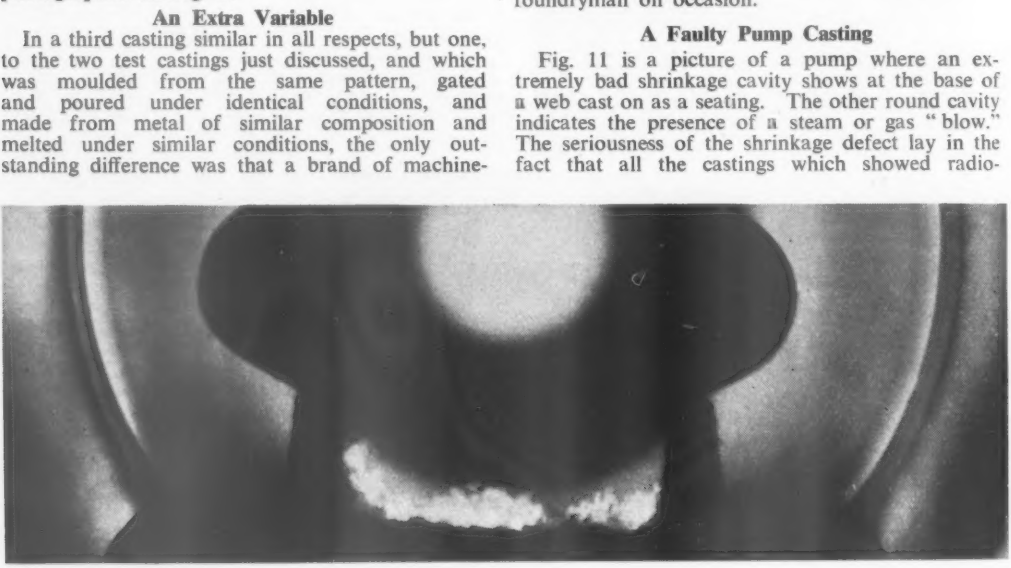


FIG. 11.—SECTION OF RADIOGRAPH OF PUMP CASING SHOWING SHRINKAGE CAVITY.

The discussion on this particular defect might be enlarged as follows:—No sudden change of sectional thickness is indicated such as would naturally lead one to expect the incidence of shrinkage cavities in this location, and no ill-conceived moulding methods were employed. It is that type of defect caused by what is known in the literature as the "Léonard Effect," and has been the subject of investigations by Fletcher and others. Briefly, it may be said that overhanging cores and projecting

parts of the mould which are partly surrounded by molten metal after filling the mould, become exceedingly hot, and in extreme cases the mould surface at that particular projection rapidly approaches the temperature of the molten iron. The resulting hot spot tends to hold the adjacent metal in a fluid or pasty state after the neighbouring parts have solidified. This is exactly what has occurred in the casting under examination. The cavity has formed just below a projecting wedge of sand which, to make matters worse, lies in the path of the primary flow of metal in the mould. In this case, there are two obvious remedies. The metal may be poured at a lower temperature, or iron sprigs may be inserted into the sand at the part in question with the object of conducting the heat away more quickly from the sand surface. The former expedient was tried with success, but, unfortunately, the lower pouring temperature gave rise to an epidemic of trapped dirt in another part of the casting. This was admittedly a tricky, but instructive problem, and finally a review of gating methods and metal composition gave satisfaction. For comparison, the radiograph of the doubtful area in a good casting is shown in Fig. 12.

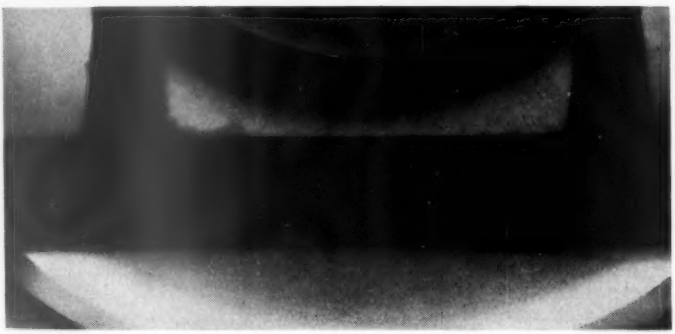


FIG. 12.—SECTION OF RADIOGRAPH OF GOOD SECTION OF PUMP CASING.

Aircraft Castings

Figs. 13 and 14 are included to show the value of this inspection method in the field of high-duty aircraft castings. Fig. 13 is of an aluminium casting with brass inserts; it appeared convincingly good on the basis of a superficial examination but, as will be seen, slight internal porosity in the region of the gate was disclosed by radiography. The casting was rejected on this evidence as it formed part of an important aircraft assembly.

Fig. 14 is the X-ray view of a die-cast aircraft component which showed marks of a suspicious character on the surface but, as is here shown, subsequent "internal" examination proved that the doubts were ill-founded. The marks were entirely surface irregularities that could be eradicated and nothing approximating to a crack existed. The casting was passed.

Foundry Investigational and Development Work

Difficulty had been experienced in the foundry with certain castings in copper-nickel. The trouble was due to the temporary lack of supplies of magnesium for deoxidising purposes, being unavailable from the usual pre-war source, and this state of affairs soon gave rise to the attendant faults which every foundryman will associate with insufficiently deoxidised metal. Various substitutes for magnesium were tried without success and, finally, the specific decided upon was manganese-boron. The experimental castings were all radiographed after treatment to determine the extent of their "inner cleanliness." Two of such castings are shown in Figs. 15A and 15B—the one which has not been deoxidised gives the usual radiographic indications of round gas inclusions while the other (deoxidised with manganese-boron) is much cleaner. Both show incipient shrinkage in the regions of the gates. The point to be brought out here is that, in the normal way, such investigation would prove rather tedious and costly, as each casting would have to be sectioned or machined and even then the information obtained would be much less complete than that gleaned from a few radiographs.

Vitreous Enamel Work

A good deal of experimental work has been done by the author on the application of refractory vitreous enamels to cast iron. This sphere of activity was more concerned with vessels and pipes which had to receive a chemically-resistant glass lining. While this might well be the subject of a separate Paper, one aspect of it embraced highly interesting radiographic results.

Over a period a technique had been developed for lining cast-iron pipe bends, straights and

Use of X-Rays in the Foundry

T-pieces with this highly resistant glass. At an early period in the development it had been observed that of all the failures there were some pipes which gave rise to vigorous and repeated "boiling" or bubbling after the enamel had fused, and of these latter castings some few gave no external indications as to the reason for this blistering, as the surface was unsullied and unscabbed. Many representative pipes were subjected, therefore, to X-ray examination and it was soon established that bad blistering was invariably accompanied by bad blowholes within the walls of the castings concerned. Figs. 16 and 17 are illustrative of a good pipe and a badly-flawed one respectively. The round gas inclusions showing on the latter radiograph are fairly representative of the enamel blistering variety and, thus, the genesis of one cause of enamelling trouble is probed in an illuminating manner by radiography.

From the above, one might well deduce interesting points in agreement with the theory of gaseous inclusion and hydrogen diffusion in cast iron put forward in 1940 by Zapffe and Sims in a Paper* read before the American Ceramic Society.

Aiding Mould Assembly

The radiograph (Fig. 18) shows the use to which X-rays may be put in the examination of mould and core assemblies in the moulding shop. It has been claimed that the accurate positioning of cores in complicated assemblies can be greatly facilitated by means of shadow pictures such as this, but the author has never found it expedient or economical to recommend such a method. When a mould does offer the possibilities of radiographic positioning of cores, it is usually found that the old orthodox methods are infinitely more speedy and easy. The method has proved very helpful as a medium of instruction in the teaching of this branch of foundry practice. The example shown here has been taken through the closed mould of a simple bush casting and the position of the centre core can be clearly seen. The more transparent spots in the picture of the mould material indicate the presence of small flakes of a denser substance dispersed through the sand. In reality, these were oxide flakes and lumps of insufficiently-milled sand.

Interpretation

In a general way, it might be wise to point out some intrinsic differences in the technique of radiographing iron as opposed to—say—magnesium. Frequently, aluminium or magnesium castings exhibit intercrystalline cracking and micro-porosity, and these defects will only show on the film when processed by a careful and experienced operator. Often the only indication of micro-porosity on the film will be the incidence of a hazy, slightly denser

FIG. 13.—RADIOGRAPH OF ALUMINIUM ALLOY CASTING SHOWING POROSITY IN REGION OF GATE.

area, very easily confused with the shadows caused by slight undulations on the surface of the casting. Intercrystalline cracks rarely lend themselves to radiographic record; it might well be imagined that a material could conceivably pass the X-ray department's test and ultimately fail in the microscopic and mechanical tests. Such does sometimes

* "Foundry Trade Journal," Oct. 3, Nov. 7, Dec. 5, 1940, and Jan. 2, Feb. 6 and March 6, 1941.

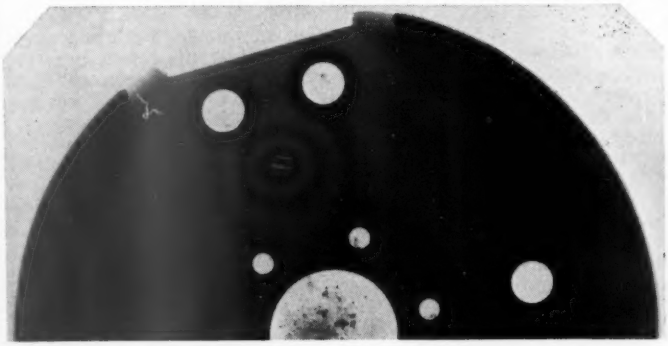


FIG. 14.—SECTION OF RADIOGRAPH OF A DIE-CAST AIRCRAFT COMPONENT.

FIG. 15A.—RADIOGRAPH OF COPPER-NICKEL CASTING NOT USING BORON AS A DEOXIDISER.

FIG. 15B.—RADIOGRAPH OF COPPER-NICKEL CASTING SHOWING EFFECT OF USE OF BORON AS A DEOXIDISER.

prove to be the case, but conversely an "X-ray reject" is never accepted by any other searching test. If a doubtful area is suggested by a radiograph, the radiologist should take two, three, or more "shots" of that area from varying angles, and thus obtain sufficient information to make a definite diagnosis. Particularly is this necessary where a crack is suspected. The appearance of a crack shadow is deceptively similar to that of a small pipe with the important exception that, on radiographing the former from various angles, the shape of the resultant shadow on the films varies with each exposure. The reason is that a crack is nearly two-dimensional, whereas a pipe is often of a cylindrical shape.

Fig. 19 is the radiographic picture of an electric-fusion cast-iron weld. The lead wires merely serve to locate the weld position. The contraction of the plates, on cooling, has given rise to a very bad crack at the centre of the weld deposit. The liability of the material to show contraction cracks is the one great disadvantage in the fusion welding of cast iron.

Position of Flaws

Sometimes it is desired to locate the exact position and extension of a flaw within the wall of a casting. To answer these questions, a double exposure technique is used. The first exposure is made with the focal spot at a measured distance from the film, and the second exposure taken with the same focal-film distance but with the relative position of the tube changed so that the focal spot is in a different situation. A double record will be obtained in which the displacement of each spot will be proportional to the distance of the flaw in the object from the film, according to the following relation:—

$$x = h \frac{b}{a + b}$$

where x = distance of flaw from film,
h = distance of film from focal spot,
b = displacement of flaw,
a = displacement of focal spot of X-ray tube.

The same principle may be applied to determine the thickness of a casting wall when it is inaccessible. The usefulness of the method may be considerable if it is desired to discover, for instance,

Use of X-Rays in the Foundry

how far corrosion of the bottom of a cast-iron pot has progressed.

Many ancillary uses for the equipment could no doubt be made by an interested foundryman. Samples of coke might be radiographed and compared with a standard to determine the degree of cellular denseness. Blacking might be jigged in an opaque container and examined under the fluoroscopic screen to give indications of the amount of coal dust present. Timber and plywood for patterns of special descriptions could, with benefit, be screened to expose knots and discontinuities before cutting. The author has, profitably, examined welded foundry cranehooks and slinghooks before commissioning them, and disclosed sub-surface defects of a highly undesirable character in equipment which, in fracturing, might have had consequences of a most serious nature.

Fluoroscopy

Brief reference has been made to the fluorescent screen; it must be said that the screen has very little value in the examination of iron and steel castings, but that for the light alloys it offers a rapid method of mass and routine inspection.

The materials used in the screens for transforming the absorbed energy into visible light are usually calcium tungstate and zinc silicate. The intensity of the rays, after passing through a solid of varying density, is proportional to the luminescence shown on the screen. Unfortunately, even under the most favourable conditions the sensitivity of fluoroscopic examination is somewhat poor, and even in viewing magnesium small porosity is often missed. Cavities under about 10 per cent. of the

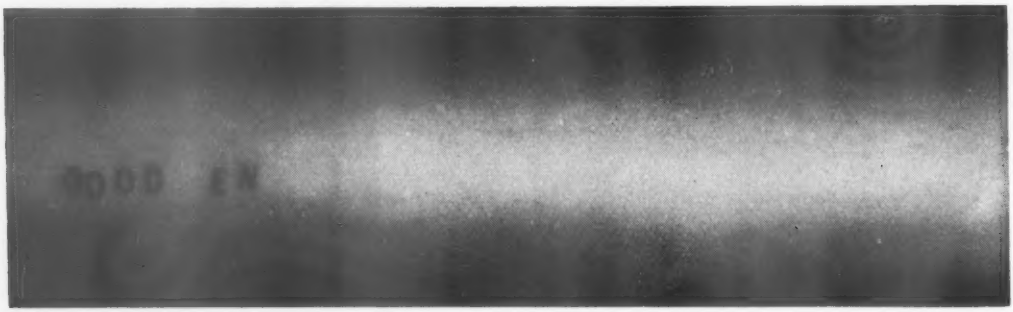


FIG. 16.—RADIOGRAPH OF GOOD ENAMELLED CAST-IRON PIPE.

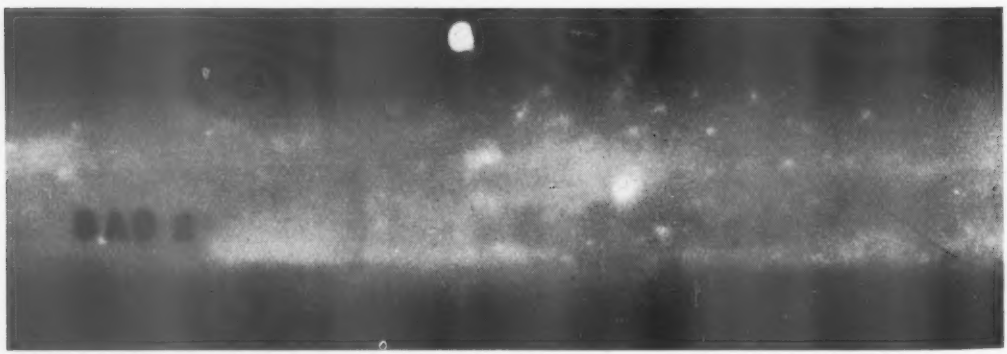


FIG. 17.—RADIOGRAPH OF BADLY-FLAWED ENAMELLED CAST-IRON PIPE.

total thickness of the section being screened are quite likely to escape detection. It would be beyond the scope of this Paper to mention at any length the finer points of radiographic technique and the "tricks of the trade" which the professional radiologist might have recourse to. It might be mentioned, in passing, that the use of grids to absorb scattered radiation, stereoscopic methods of giving radiographs a three-dimensional perspective, and the clever method of showing in detail flaws in one plane or stratum of an object while blurring out all faults in every other plane, called tomography, are collectively of purely scientific interest.

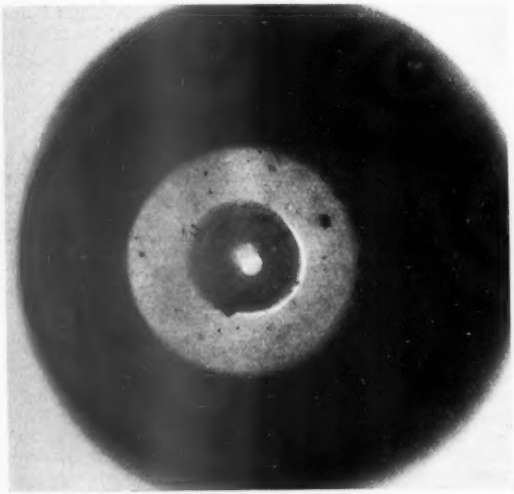


FIG. 18.—USE OF X-RAYS FOR EXAMINING MOULD AND CORE ASSEMBLIES IN THE MOULDING SHOP.

The use of radium emanations in radiography is also purposely omitted, although the author considers that radio-active materials will be harnessed to this purpose more in the future than they are to-day.

Safety Precautions

It might not be amiss if some reference was made to the physiological effects of X-rays for the benefit of prospective purchasers of equipment. Modern tubes are well insulated, protected, and well-nigh foolproof, but still provision must be made for the protection of personnel. One particular effect of X-rays is that they ionise the air in the vicinity of the tube; hence it is very desirable to have adequate ventilation. This removes any unwelcome vapours which might possibly be present as well as removing any danger of short circuits.

X-rays adversely effect human tissue and, these effects being cumulative, the operators should not be permitted to work for extended periods in close proximity to the radiating tube. The reputable firms which instal these equipments always point out the dangers and advise as to the best methods of equipping the proposed laboratory.

If the use of X-ray equipment in the foundry is confined solely to the inspection department,

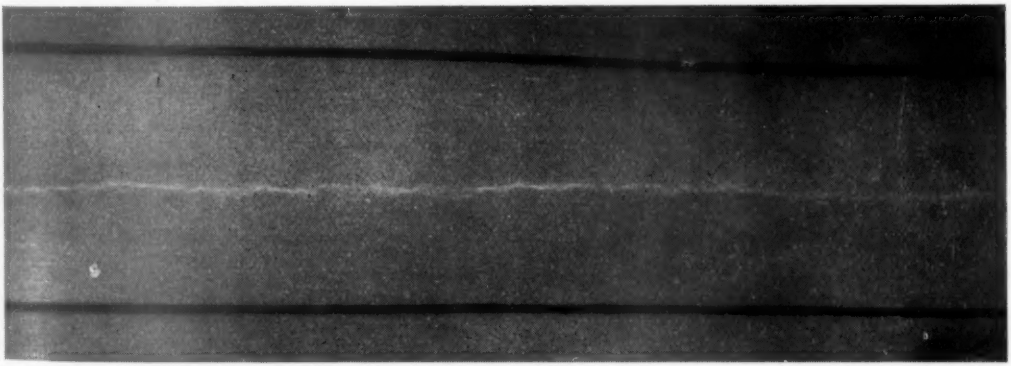


FIG. 19.—RADIOGRAPH OF A CRACK IN AN ELECTRIC-FUSION CAST-IRON WELD.

Use of X-Rays in the Foundry

then its capabilities as an engineering tool are being neglected. The fact must be borne in mind that X-ray examination is the only reliable non-destructive test for metals in existence. The following hypothetical case might illustrate this point: Let it be supposed that in a foundry possessing such equipment an entirely new production line is being considered. Taking for granted that the combined planning of designer, patternmaker and moulder has resulted in what is thought to be a feasible mode of attack, two or three test castings should be made in accordance with the design adopted, and each of these systematically radiographed.

The positions of recurring flaws should be noted: their nature, distribution and probable causes commented upon (in co-operation with the foreman moulder) and steps taken to adjust the methods of production or to alter the design in order to circumvent these pitfalls in the castings which follow up. Very often no alterations are necessary. Sometimes several pilot castings are produced before things settle into a normal run but whichever happens to be the case, it can be safely taken for granted that time is saved, much scrap avoided, and considerable waste eliminated from machining costs.

Conclusion

In attempting to stress the known and potential foundry applications of radiography, it will be appreciated that many interesting and important developments in other fields have necessarily been given scant mention. It is a branch of applied science which is as yet barely past its teething stage, although anyone interested will find that a considerable amount of literature has been written on the subject.

Again, consider what a potential sales argument in favour of foundry products a radiograph or two can be. The prospective customer is often quite unimpressed by talk of 20 tons tensile in a cast iron. To him, no benefit accrues by loading an iron with expensive alloys unless he can be reasonably sure that he is buying an internally sound casting. This is particularly true in these days of high-duty-iron specifications, and, no doubt, is an impeding factor in the substitution of iron castings of recognised physical characteristics for more expensive fabricated parts.

Although the perfect casting may be as unobtainable as the "philosopher's stone," it is neither impossible nor difficult to attain absolute soundness in important or highly stressed sections of the individual casting, if intelligent foundry control, aided and abetted by radiography, is practised. Added confidence could be placed in castings as engineering materials, and this, naturally, would reflect favourably on the foundry industry as a whole.

Finally, the author records his thanks to Mr. W. Lindsay Burns, managing director of Henry Balfour & Company, Limited, Leven, for permission to read this Paper, and publicly acknowledges his indebtedness to him for the keen interest he takes in industrial science.

ALUMINIUM PRODUCTION IN U.S.

DR. ZAY JEFFRIES, of the U.S. National Research Council, has presented a report to W.P.B. on the production of aluminium from domestic raw materials. Until recently, aluminium production in the United States had largely been confined to the use of high-grade low-silica and imported bauxite employing the Bayer process. Because of difficulties arising out of the war it has now become necessary to utilise domestic material which contains rather a high percentage of silica.

In reporting on a washing process by which the silica content of high-silica bauxite may be reduced, making the ore available for economic treatment with the Bayer process, the investigating committee states that the original plan to add limestone and soda to the high-silica bauxite and then to sinter this mixture has been changed. It now is planned, at one plant, first to put all the bauxite directly through the Bayer plant, thus running it entirely on high-silica material. About 70 per cent. of the contained alumina will be removed directly. The tailings, or "red mud" (so-called because of the colour it gets from contained iron), will then be subjected to the lime-soda sintering operation. The sintered product will be leached and the liquors will be added to the Bayer process liquors. The tailings from this operation will contain very little alumina.

Recovery of alumina from a ton of high-silica bauxite, treated this way, is expected to be comparable to recovery from a ton of low-silica bauxite when treated with the Bayer process alone.

The report recommends consideration of installation of such sintering plants at the other Bayer process plants in America. It recommends extraction of alumina in millions of tons of "red mud" that have accumulated during the years that the Bayer process has been in use.

It also recommends a modified Pedersen process for production of alumina from clay in which there is no dependence on a Bayer plant. This process, in brief, consists of sintering the clay with lime and subsequently leaching with soda; further research work will be required to develop this process.

The committee reports, too, that work also is going forward with a promising acid process for the treatment of alunite.

UTILISING ATMOSPHERIC PRESSURE IN MAKING STEEL CASTINGS

A New Technique in Gating and Risering Employing "Blind Risers"

By HOWARD F. TAYLOR and EDWARD A. ROMINSKI

(*Continued from page* 139.)

In making laboratory test castings, 36 in. high with a 9 in. high blind head, the walls persistently collapsed in the top 6 in. To overcome this a larger downgate and sprue system was used which remained liquid and kept the internal pressure against the casting walls greater than atmospheric throughout the system, until the shell of metal formed was strong enough to resist deformation. This height was nearing the limit to which atmospheric pressure can force metal upward, and the blind head did not supply the early feed demand unassisted but was, however, able to accomplish necessary feeding by the time the enlarged sprue system solidified.

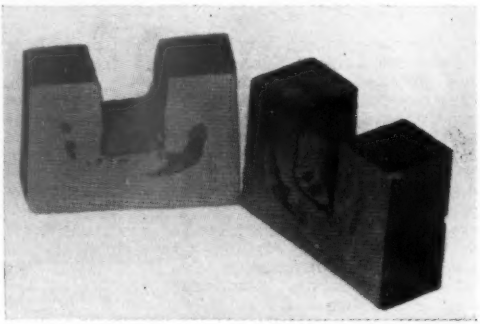


FIG. 14.—ATMOSPHERIC PRESSURE BREAKING THROUGH THE SOLIDIFIED SHELL OF A HOT SPOT.

In instances when shrinkage is compensated for externally, the walls of the casting will be sound, and occasionally in thinner members the whole section will be solid. The latter is an example of internal shrinkage being completely accounted for by external shrinkage. Atmospheric pressure sometimes acts in another way even more detrimentally to the internal integrity of the casting. The large number of blowholes and cavities which occur in the region of congested areas of sand, such as internal angles, can also be laid directly to the same combination of influences that cause the walls of castings to collapse. Fig. 14 shows a photograph of a typical defect of this kind. The exaggerated shrinkage seen in the left leg of the keel block is the result of atmospheric pressure acting in a manner analogous to a blind head with the sharp wedge of sand creating the necessary hot spot.

The shrinkage which would normally have been equalised between each leg is decreased in the right because it was partially fed from the left. The manner in which this takes place is thought to be as follows: Since feeding was purposely inadequate, shrinkage occurred in the casting. The skin of solidified metal which forms at the sand-metal interface thickens at a rate which is dependent upon the cooling surface. Naturally, the areas of sand on the open faces of the casting conduct heat away rapidly with a maximum rate of solidification, as shown in Fig. 15. The sand in the internal angles cannot conduct heat away rapidly; hot spots exist in the casting at these points and the skin formed is relatively thin and weak.

Fig. 16, taken from work at this laboratory by Briggs and Gezelius, shows more clearly perhaps the relative trends of skin formation on internal and external angles. This particular casting was made in a vertical position and poured through the large end, which was uppermost. After one minute the mould was inverted and the casting bled. In a similar mould, at the end of five seconds, the average wall thickness on the outer surfaces was $\frac{3}{16}$ in., while at the internal angles the wall was paper thin and the sections broke apart at this point. Whenever such a condition exists, it is quite often in the region of a heavy section and, with shrinkage tending to form a partial vacuum within the casting, the atmospheric pressure acts to rupture the wall at its weakest point and forces a hole into the casting at the hot spot to relieve the partial vacuum inside. Fig. 14 is a typical example of this type of defect, which is not uncommon in steel castings.

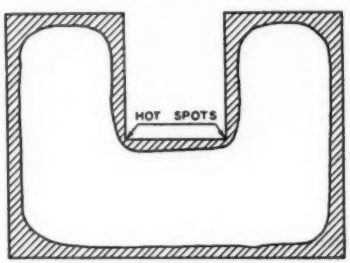


FIG. 15.—SKETCH SHOWING RELATIVE RATES OF SKIN FORMATION AT INTERNAL AND EXTERNAL ANGLES.

One foundryman describes similar defects as being

Atmospheric Pressure in Casting Steel

caused by a "Leonard Effect," which is explained as "... gases escaping from a congested part of sand, strongly heated by metal and not sufficiently permeable to allow the amount of gases produced to escape to the exterior of the mould." The writer goes on to say that, "in many cases, a waster had been brought

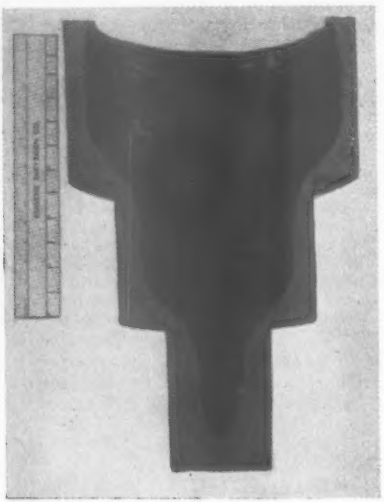


FIG. 16.—CASTING SHOWING RELATIVE RATES OF SKIN FORMATION AT INTERNAL AND EXTERNAL ANGLES.

to the author for advice in which holes had been the result of 'Leonard Effect,' while the questioner thought it was either wrong metal, or shrinkage cavities, or something else." The writer also stresses the point that this "Leonard Effect" should not be confused with real shrinkage cavities.

The peculiar feature of this effect is that it is apt to occur in dried sand moulds and in sands of high permeability, and it normally depends upon real shrinkage for its initiation. If the cause is as simple as the formation of excessive gas pressures, the provision of highly permeable sand should solve the problem. There is no doubt that excess gas pressures and lack of permeability are contributing causes in many cases, but that they are not entirely responsible is shown in a rather striking manner by Figs. 17, 18 and 19. The casting of Fig. 17 is a round bar into which a thermocouple was cast. This bar was used as a temperature control for a duplicate bar poured simultaneously and identical in every respect except for the absence of a thermocouple. Fig. 17 shows how the mould was assembled. The thermocouple wires were platinum and were protected by a two-hole

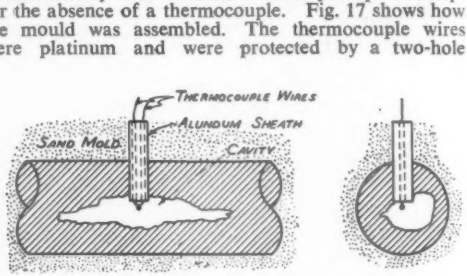


FIG. 17.—CAVITY IN CAST BAR CAUSED AT ATMOSPHERIC PRESSURE ACTING THROUGH THE ALUNDUM TUBE.

alundum sheath which was open at each end. After pouring the castings, discrepancies in the temperatures recorded often indicated something amiss and, upon sectioning such castings, a cavity was always found. In some cases the temperature would be as expected, and in these cases sound metal was found around the thermocouple bead. The variation in results from time to time indicated something unusual and for a while it was thought that oil or other gas-forming substances might be present which would expand at the high temperatures involved and create the excessively large cavities. In spite of utmost care exercised in keeping the tips clean, the cavities persisted in recurring. The phenomenon causing this unusual condition was evidently somewhat out of the ordinary.

FIGS. 18 AND 19.—PHOTOGRAPHS OF ACTUAL CASTINGS MADE WITH OPEN AND CLOSED THERMOCOUPLE SHEATHS TO ILLUSTRATE THE INFLUENCE OF ATMOSPHERIC PRESSURE.

Atmospheric Pressure in Casting Steel

After studying all other possible causes it was decided that perhaps atmospheric pressure was being transmitted through the holes of the alundum sheath into the centre or liquid part of the bar where a shrinkage cavity was tending to develop. The atmospheric pressure localised the shrinkage into one large cavity. The obvious remedy was to use a closed sheath to prevent this easy admittance of air, and when this was done solid castings were always obtained. Figs. 18 and 19 show a cross-section of castings made with the open and closed sheath, respectively.

In several experimental castings where defects were initiated at hot spots, it was necessary to examine the casting microscopically in order to detect the small opening from the cavity to the outside of the casting, but with enough care one was always found.

The physical properties of castings are the same whether made with open or blind risers if each is properly applied. The results shown in Table I tend to bear out this statement, as do the many tons of radiographically sound and pressure tight castings made daily by each method. The "A" specimens were cut from the bottom of the gravity fed coupon of Fig. 20 and the "B" specimens from the top of the coupon fed with a blind head (Fig. 21). As might be predicted, the additional "ferro-static" or gravity head has not produced castings with better mechanical properties than those fed with atmospheric pressure alone.

Figs. 22 and 23 represent schematically a layout for the use of a blind head for feeding the heavy section of a casting. In attempting to clarify the nomenclature, it is suggested that definite terms be adopted in referring to a blind head feeding assembly. In this Paper the channel "AA" leading from the downgate to the head will be the "ingate" and "CC"

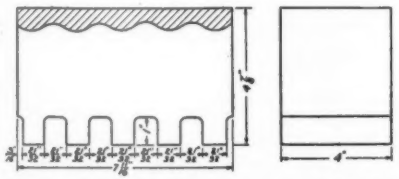


FIG. 20.—TEST COUPON MADE WITH OPEN RISER.

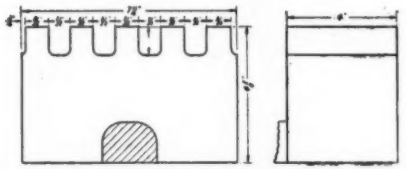
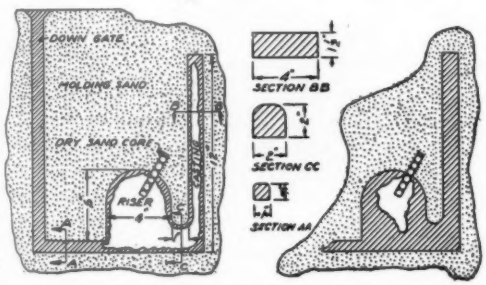
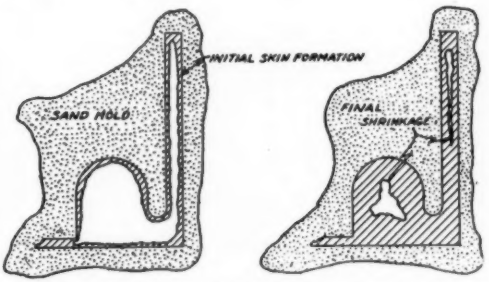


FIG. 21.—TEST COUPON MADE WITH BLIND RISER.



FIGS. 22 AND 23.—SCHEMATIC DRAWING OF MOULD AND CASTING TO ILLUSTRATE THE PRINCIPLES OF BLIND HEAD FEEDING. ON LEFT, PARTLY SOLIDIFIED, AND ON RIGHT, COMPLETELY SOLIDIFIED.



FIGS. 24 AND 25.—SCHEMATIC DRAWING ILLUSTRATING (LEFT) INITIAL SKIN FORMATION AND (RIGHT) FINAL SHRINKAGE IN A CASTING UNSATISFACTORILY FED BECAUSE THE BLIND HEAD WAS NOT KEPT OPEN TO THE ATMOSPHERE.

TABLE I.—*Comparison of the Physical Properties of Steel Castings* Fed by Means of Open and Blind Risers.*

Specimen.	Yield strength, tons per sq. in.	Tensile strength, tons per sq. in.	Elongation in 1½ in. per cent.	Reduction of area, per cent.
A1	28.5	35.0	30.2	65.4
A2	28.2	34.4	30.2	66.3
Ave.	28.3	34.7	30.2	65.9
B1	28.6	34.6	30.2	68.0
B2	28.2	34.2	32.2	68.0
Ave.	28.4	34.4	31.2	68.0

* Chemical analysis (per cent.)—C, 0.13; Mn, 0.70; Si, 0.95; Cu, 1.69; S, 0.03; P, 0.03.—Specimens dead annealed.

Atmospheric Pressure in Casting Steel

leading thence into the casting will be referred to as the "neck." This follows the terminology of most shops familiar with blind head feeding.

The sketch shows the casting actually 5 in. higher than the top of the blind head. In the manufacture of average commercial castings, such as valves, for which the blind head is especially suited, this situation seldom exists. In general the mass of the flange or other section is great enough to require a blind head very nearly as high as or slightly higher than the part it is to feed, especially since the bottom of the riser is placed at or slightly below the parting line. In these examples, as in blind risering in general, the metal poured into the ingate must flow first through the riser and then into the casting.

As soon as the mould is completely filled, the metal loses temperature rapidly to the sand, and a skin of solid metal quickly forms at the mould-metal interface. This initial skin formation is shown as the cross-hatched areas of the figure. As temperature continues to drop, more and more metal solidifies, and the liquid shrinkage accompanying the falling temperature tends to form the partial vacuum within the solidifying mass. The skin forming on all parts of the casting is impermeable except at the desired spot on the riser. In this case as solidification continues in the casting proper, the atmospheric pressure plus any gas pressure in excess of this value acts like a piston on the metal in the blind riser, forcing it into the casting to feed shrinkage. In other words the system is functioning like a mercury barometer. Shrinkage is constantly tending to create the necessary partial vacuum in the casting and atmospheric pressure, acting through the medium of the molten metal in the riser, is constantly relieving it. If solidification proceeds properly, with the parts most remote from the riser freezing first and progressing thence toward the riser, each successive amount of shrinkage is compensated by additional fluid metal forced in from the riser. The ingate, being small, freezes off first and completes this part of the closed system. Figs. 24 and 25 show a similar system in which a completely impermeable skin forms, and shrinkage takes place independently in casting and riser with the resulting cavities.

Figs. 26, 27 and 28 show examples of keel-block castings made with a blind head. Fig. 26 shows the manner of casting, and Figs. 27 and 28 show the castings sectioned. In one case the riser is kept open to the atmosphere and in the other it is not. In Fig. 27 solidification has taken place independently in the casting and in the riser, while in Fig. 28 the total shrinkage is accounted for in the riser alone. As many as five such castings have been made from a single blind head. It is only necessary that the volume of metal in the blind head be greater than that necessary to compensate for the liquid shrinkage of the system before final freezing of the riser.

Figs. 29 and 30 show the top and side view of a typical method of feeding a valve flange with a blind riser. The sketch is largely self-explanatory.

Several means can be used for keeping a blind head open. As a matter of fact in cases where very hot metal is used and an early feed demand develops in the casting the riser may break through without any artificial means being provided. However, this is far too uncertain to depend upon. A sharp wedge of sand may be moulded into the top part of the riser, and in many cases this method is satisfactory. The sharp edge of the wedge of sand sticking down into the metal furnishes the necessary hot spot, but as in the

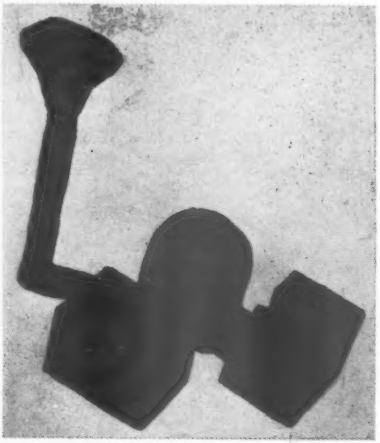


FIG. 26.—METHOD OF MAKING KEEL BLOCK CASTING WITH A BLIND RISER.

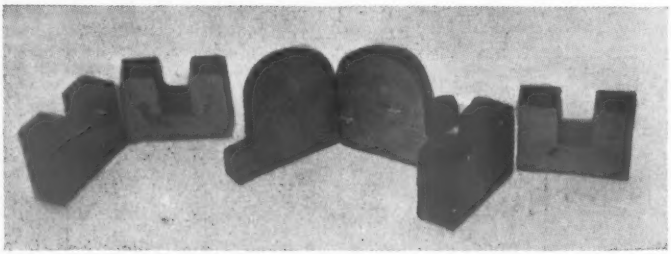


FIG. 27.—KEEL BLOCK WITH RISER CLOSED TO ATMOSPHERE.

Atmospheric Pressure in Casting Steel

case above cold metal and late feed demand may often combine to cause this method to be ineffective. The use of thermit either made up as a core or held in readily melted metal tubes placed at the top of the riser has been found satisfactory by some foundrymen, and actually increases the efficiency of blind risers by the exothermic addition of heat. The material is expensive, however, and this method will probably not become popular for that reason. These methods have all been tried at the Naval Research Laboratory, with the results reported above, and none appeared to function with the same degree of certainty and simplicity as the dried sand core. The method developed by the Dodge Steel Company consists of imbedding a round dried sand core in the sand at the top of the blind riser so that it extends into it for a distance roughly equal to the radius of the riser in the manner shown in Fig. 30. This is a simple rod core of a type found in the average foundry except that a small vent hole extends through the centre. This vent hole is not essential, but is recommended. The only provision is that the core be made sufficiently strong and refractory to withstand the pressure and temperature of the molten metal, and permeable enough to allow passage of gas.

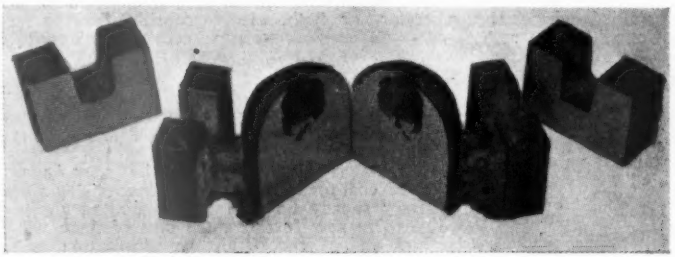
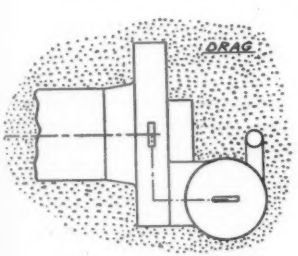


FIG. 28.—KEEL BLOCK CASTING WITH RISER OPEN TO ATMOSPHERE.



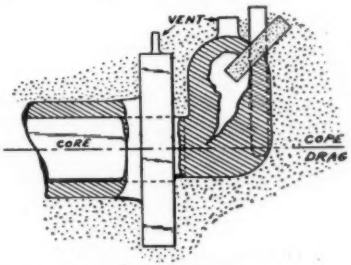


FIG. 29.—(LEFT) SKETCH SHOWING TOP VIEW OF VALVE FLANGE MADE WITH BLIND RISER.

FIG. 30.—(RIGHT) SKETCH SHOWING SIDE VIEW OF VALVE FLANGE MADE WITH BLIND RISER.

Further development may in time bring to light other methods even more useful for certain applications. Several methods have been tried, but have proved either more complicated or more expensive than the simple core. In action the core breaks the seal which would otherwise form completely over the riser by extending into the centre where there is still liquid metal. Thus atmospheric pressure, acting through the permeable core, is able to force the metal from the riser into the partial vacuum tending to form within the casting proper. The sand of the mould is sufficiently permeable to allow an easy passage of gas to and from the core so that the full benefit of atmospheric pressure is realised. It has not yet been definitely determined whether the gas generated instantaneously by the core is necessary to initiate the contact with the atmosphere, but it is added assurance.

After understanding the principles behind blind risering it is readily apparent that sand cores can be used to advantage in open risers to prevent secondary shrinkage. By securing them in the sand at various levels with one end protruding into the centre of the open riser, they prevent the possibility of the riser cutting off atmospheric contact by freezing over.

Foundry Considerations in the Use of the "Blind Riser"

For many castings considerable advantages in economy and convenience are possible through blind riser feeding, but naturally whether to use it or the alternate and more common method of feeding with open risers should be decided on the basis of casting design. No fixed rules can be given at present regarding when blind heads are to be preferred to open types, but with a few basic facts and a progressive attitude the average foundryman can determine his practice from a relatively short experience with the method. In general it may be said that blind riser feeding has found its greatest application in the light and medium light casting fields; that is, in castings weighing less than a ton. Some of the advantages and disadvantages of the method follow in detail.

(To be continued.)

FUELS FOR MELTING FURNACES IN LIGHT-ALLOY FOUNDRIES

A 24-page survey of the position in regard to the use of fuels other than fuel oil in melting furnaces of light-alloy foundries has been prepared by the Technical Committee and issued by the Light Metal Founders' Association, 25, Bennetts Hill, Birmingham, 2. It is unquestionably excellent and the applications of its precepts are by no means confined to the field indicated in the title. Actually most non-ferrous founders would benefit from a close study of its contents. As the publication is intended primarily for the members of the issuing association, and copies may not be available for allied industries, the conclusions arrived at by the Committee are set out below:—

A.—New Installations

(*a*) *Reverberatory Open-Hearth Furnaces* of 1 ton and upwards capacity prove very satisfactory where conditions regarding the demand for metal in the foundry justify their use. They are usually fired, by hand, with coke; but can also be fired with coal. In the latter case firing can be by automatic underfeed stokers, which give automatic and accurate control of combustion and temperature, with increased economy of fuel.

Coke firing, if dry coke is used, gives completely satisfactory results so far as condition of metal is concerned. Doubt is expressed as to the danger of hydrogen pick-up if coal is used, but this is by no means certain, and needs investigation.

(*b*) *Smaller Reverberatory Furnaces* of the barrel type can be fired by oil, town's gas, producer gas, or creosote/pitch.

(*c*) *Large Crucible or Pot Furnaces*, whether tilting or stationary, can be fired by oil, town's gas, producer gas, or creosote/pitch. It is considered they could be successfully fired also with pulverised coal, in which case the fuel cost would be extremely low. Tests shortly to be put in hand will establish whether or not the use of pulverised coal is really as satisfactory as is anticipated.

(*d*) *Die Shop Furnaces Used for Maintaining* can be fired by oil, town's gas, or producer gas. It is probable that they can also be successfully fired with pulverised coal, as to which the same remarks apply as in the last paragraph. It is understood that for furnaces with a lower minimum rate of oil consumption than about 1 gall. per hr. the use of creosote/pitch is not, as yet, likely to be free from trouble.

A very attractive design has been put forward for a single pot maintaining furnace using raw coal fired by means of an underfeed stoker. This design will shortly be tried out in practice and, if successful, would provide a very economical unit, the capital cost of which would not be unduly high.

B.—Conversion or Adaptation of Existing Installations to Use Fuel Other than Oil or Town's Gas

(*a*) *Large Crucible or Pot Furnaces.*—These can be changed over, without modification except slight alteration to the burner valve, direct to creosote/pitch; provided the necessary distribution system for that fuel is available. Producer gas may also be used, but this will probably need some modification to the furnace either by way of increased combustion space, or the addition of a recuperator, or both. It is probable that pulverised coal could be used, with very economical results.

(*b*) *Medium Crucible or Pot Furnaces.*—These can be changed over, without modification except to the burner and/or burner valve, direct to creosote/pitch or producer gas. In the latter case it may be found that melting times will be somewhat increased, but this can be countered either by using an iron pot instead of a crucible, or by the addition of a recuperator, or both. It is probable that pulverised coal could be used, with very economical results.

(*c*) *Die Shop Furnaces Used for Maintaining.*—These can be changed over, without modification except to the burner, direct to producer gas. The use of creosote/pitch is not recommended at present for furnaces with a consumption of less than about 1 gall. per hr.

Attention is also drawn to the remarks under A (*d*) *re* coal-fired maintaining furnaces. This design will very shortly be tried out, and although its use will involve new furnaces, the cost of these will not be high and, if successful, the substitution of such furnaces for some existing oil-fired furnaces may be well worth consideration under the heading of an emergency alteration. At the same time the fuel cost is likely to be very low.

It is probable that, with some suitable changes in design, pulverised coal could be used, with very economical results.

The Provision of Emergency Standby Equipment

All the measures envisaged under B above in regard to melting furnaces involve considerable capital expenditure. Although those remarks have been confined to the conversion or adaptation of existing installations, and although in most cases any modification of existing furnaces would not be a costly matter, it is necessary in every case to install entirely new systems for preparing the fuel and for conveying it to the furnace burners.

While the provision of these alternative systems would not in most cases interfere with the continued running of the furnaces on their present fuel, it will inevitably be a source of high capital expenditure, and take a considerable time.

Attention should therefore be drawn most strongly to the possibility of providing against emergency quickly and at relatively low cost by the provision of furnaces of the crucible or pot type suitable for burning coke. Such furnaces, of the pot type, may be cheaply constructed and kept in readiness for use in case of emergency; or, on the other hand, certain standard types of self-contained transportable units are available which can be placed anywhere when required, and merely connected up to the power supply.

The Committee believe that the purchase now of a

(*Continued on page* 129.)

METALLURGY OF INDUCTION HEATING

The principles and metallurgy of induction heating are discussed by A. F. MACCONOCHIE, of the University of Virginia, in a recent issue of "Steel." Perhaps no other field of applied science, he says, has extended its boundaries so rapidly within this present generation as induction heating. Inaugurated some 25 years ago, it has become almost indispensable in the battle of production for it is continually finding new and useful applications in the manufacture of airplanes, tanks, guns, shells, engines and machines.

For the purposes of surface hardening, for example, high-frequency alternating electric currents of some 2,000, 10,000 or upward of 100,000 cycles per second are carried through inductor coils in such a manner that the resulting magnetic field cuts that portion of the work that is to be heated. When a magnetic material, such as steel, comes within the influence of this field, each molecule of the steel tends to align itself in the direction of the magnetic lines of force, each individual molecule behaving exactly as though it were a tiny magnet having a certain freedom of rotation. As the polarity of the field changes, the effort of the molecules to adjust themselves causes energy losses which appear as heat. This effect tends to be concentrated near the surface for metal below is partly shielded by that above. The higher the frequency, the more marked does this effect become. It is known as the skin effect and the frictional action that produces heating of the steel is called hysteresis, a characteristic closely related to the magnetic qualities of the steel.

As the temperature of the steel increases to the critical point, it becomes nonmagnetic, the alpha form giving away to gamma iron in which the carbides are dissolved. Beyond the critical range, when the steel is in the austenitic state, all hysteretic heating ceases and heating depends entirely on eddy currents caused by changes in the flux. Even below the critical temperature these eddy currents are largely responsible for the heating effect, since hysteresis plays a minor role. Many nonmagnetic materials such as aluminium, copper and carbon can be heated readily by electric induction because of the effect of these eddy currents. Thus almost any nonmagnetic substance that conducts electricity readily can also be heated by electric induction.

Another characteristic of steel which has an important bearing on the result of exposing it to a rapidly changing magnetic field is the increase in electrical resistance as the temperature rises. As the temperature reaches quenching level, this characteristic decreases the intensity of the effect of the eddy currents to a fraction of its original value while the steel was cold. Since also there is a tendency toward the concentration of the heating effect in the region near the surface of the piece, the extent to which the austenitic state extends towards the interior is readily adjusted by controlling the frequency, the amount of power supplied, and the period of application.

As might be expected, the rapidity of the heating rate as compared with conventional methods produces certain physical differences in the product. While many minutes may be necessary to bring the piece up to quenching temperature in an ordinary gas or oil-fired furnace, induction heating may put the carbides in solution in less than a second. Such speeds can attain maximum hardness and absence of carbides in plain carbon steels having carbon contents as high as 0.5 per cent. In any case, the solution rate is such as to involve no more than a matter of a few seconds.

Metallurgy of the Process

In discussing the matter before the Electrochemical Society, Dr. H. B. Osborn, Junr., of the Ohio Crankshaft Company, Cleveland, said that in view of the extremely rapid transformation of pearlite to austenite accomplished by induction heating and the tendency for this to occur between the lower and upper limits of the critical range, a considerable amount of free ferrite might be anticipated. This, however, is not the case unless the heating is stopped at the instant diffusion has been completed within the ferrite boundaries. There is a preferential removal of carbides over ferrite, and a major portion of the ferrite persists until most of the carbides have become diffused.

The next step in this rapid diffusional process involves the removal of free ferrite and the formation of a fine homogeneous structure which is retained on quenching. He further notes that induction heating has a stimulating effect, apparently, on carbide solution and the production of a homogeneous austenitic condition. This in turn gives rise to a fine, nodular type of martensite that is more readily apparent in plain carbon steels than in alloy steels on account of the nodular characteristics of most alloy martensite.

The essential elements composing surface-hardening equipment include, of course, the inductor itself, which may be a single turn of copper designed to fit the piece to be hardened or may consist of several turns of copper tubing suitably shaped. In addition, suitable arrangements must be provided to supply the quenching medium through orifices; a transformer and capacitor; automatic timing controls; and a high-frequency generator. While some consideration must be given to the design of the inductor for any given piece, it appears entirely satisfactory to induction-harden pieces of irregular shape because of the natural tendency of the rapidly fluctuating magnetic field to follow the contour of the part. Automatic timing controls eliminate the human element completely and easily attain a degree of accuracy within 0.1 sec.

In selecting the frequency for any particular task, consider that if a surface heat is desired, high frequency and high power are required; while if the piece is to be heated uniformly to some depth (as for forging), the frequency selected must allow the necessary depth of penetration and the power must be low enough to permit transmission of heat to the interior by conduction without overheating the surface

(*Continued on page* 178.)

DURABILITY OF MOULDING SANDS

In a "Progress Report" which Mr. Jack CoVan presented to the American Foundrymen's Association on the relative durability of naturally-bonded and synthetic mouldings, use was made of the "repeated pour test." Originally devised by Mr. C. M. Nevin, it consists of tempering a specimen of sand to optimum working condition and testing it by the standard A.F.A. bar test for green strength. Then a test mould is rammed with this sand. The cavity in the test mould is cylindrically shaped and the ratio of the weight of metal contained in the cavity to the weight of sand is such that the strength of the sand is reduced by a practical amount each time molten metal is poured into the test mould.

After the mould is prepared and molten cast iron is poured into it, the casting is allowed to cool to room temperature. The casting is then "shaken-out" and is brushed or scraped free of sand. The entire amount of sand is then remixed, and water again is added to temper the sand to optimum working condition. The standard A.F.A. bar test is repeated for the green strength. The cycle is started again with the ramming of the second test mould. This procedure is repeated for ten times or "heats." A decrease in green strength of more than 20 per cent. is said to indicate a sand with undesirable durability.

From his investigations, the author has drawn the following conclusions:—

(1) The five sands used in these series of tests include three synthetic sand mixtures and two naturally-bonded sands. Each of the synthetic sands was bonded with one of the three recognised classes of clays, namely, kaolinite, montmorillonite, and illite.

(2) The results of tests on the sand samples bonded with these various type clays may be used as a guide to the durability of synthetic sand mixtures in commercial foundries when such sands are used under conditions similar to those existing in the series of tests.

(3) The durability values obtained on the naturally-bonded sands show that, under the conditions of these tests, the amount of natural clay bond needed to produce 6 lbs. per sq. in. green compression strength throughout the test series was at least twice as much as that required for synthetic sands to maintain the same strength.

(4) Based on additions of new sand, it might be possible that none of the original naturally-bonded sand sample existed in either of the two naturally-bonded sands tested after the final test. In the case of the Eastern naturally-bonded sand, 6,860 grammes of new sand were added in the ten heats, and in the case of the Midwestern naturally-bonded sand, 4,960 grammes were added. In both cases, the original sample weight was 3,000 grammes.

(5) The above results seem to indicate that synthetic sands have a greater durability than do natural sands.

(6) Whether or not the data obtained on the two natural sands tested are applicable to all types of natural sands is doubtful, as the results obtained with other naturally-bonded sands would depend upon the mineral constituents of the natural clay bond.

(7) The data obtained in this investigation have produced durability values on specific sand mixtures which can serve as a basis for correlating the results obtained in future work in connection with the invention of a rapid and reliable laboratory method for determining the durability of foundry sands.

(8) Data accumulated in a series of tests with samples of each type sand tempered to contain 1 per cent. more moisture than the best workable moisture content appear to indicate that tempering sands to the wet side has little effect on the durability.

(9) Further investigation may be indicated with regard to the possibility of connecting the determination of durability values with dry compression strength instead of green compression strength.

METALLURGY OF INDUCTION HEATING

(*Continued from page* 177.)

if uniformity of temperature is to be secured throughout the cross section.

Advantages of Process

In the case of melting installations, since the diameter of the charge is uniform, it becomes possible to select the most economical frequency for each particular metal. An important advantage of induction heating in melting is that the metal contacts only the refractory lining and the air above it, so no contamination from external sources can occur. Thus, save for possible de-gasification during melting, the resulting product is the sum total of the original contents of the crucible.

Further, a stirring action is produced by the alternating magnetic field, which if moderate, assists in refining and mixing the charge. The degree of agitation is most marked at low frequencies. Then, too, while starting up with broken scrap, the electrical discontinuity of the charge calls for a high induced current to initiate the heating which at low frequencies implies a heavy primary current since the heating effect is proportional to the square of the product of ampere turns and frequency. Thus from several points of view it is advantageous to employ fairly high frequencies in induction melting operations.

The successful applications of the practice of induction heating to surface hardening, forging and melting cover a wide field. Such diverse accomplishments as the hardening of the nose shell of the armour-piercing type, the surfaces of crankshaft bearings, the internal surfaces of cylinders for airplane and Diesel engines, the wearing surfaces of bearings, and rolls, shear blades, rail surfaces and so on, are everyday achievements; while annular pieces such as the tyres of railroad car wheels and gun liners are readily heated by these means for shrinking in place. For forging purposes, uniform temperatures are readily attained in the blank—a most important consideration, since any variation in the temperature between one side and the other, or between the inside and outside, will probably result in eccentric blanks.

EXPORT LICENSING EXTENSIONS

Under the Export of Goods (Control) (No. 40) Order, 1942, which comes into force on November 2, licences will, in future, be required to export the following classes of goods to all destinations: Crucibles, plumbago (graphite); briquetting plant and moulds for briquette presses; ships' propellers; nickel compounds and mixtures containing any of these compounds.

Applications to export briquetting plant and moulds for briquette presses should be filed through the Brickmaking, Clay-working and Briquetting Machinery Export Group (Peat, Marwick & Mitchell), 94-98, Petty France, London, S.W.1.

The control in respect of door and window frames and casements, hollow-ware, wire fencing and wire mesh is no longer confined to goods manufactured wholly or mainly of iron or steel, but is extended to cover all such goods made wholly or mainly of metal. Applications to export any of these goods manufactured from non-ferrous metals will not, normally, be entertained. Copies of the Order are now available from H.M. Stationery Office.

Under the Export of Goods (Control) (No. 34) Order, 1942 (S.R. & O. 1640), which came into force last month, control is extended to cover additional metal manufactures, machinery, electrical goods and chemicals.

Licences will, in future, be required to export the following classes of goods, among others, to all destinations: — Washing machines, mangles and wringers; wire-weaving machinery; and flat irons. Applications to export washing machines, mangles and wringers will not, normally, be entertained.

Existing controls have been extended to cover hand and bench tools (and parts thereof) made wholly or mainly of metal and all kinds of containers (including flattened containers) and hollow-ware.

FUELS FOR MELTING FURNACES IN LIGHT-ALLOY FOUNDRIES

(*Continued from page* 176.)

number of such units offers a cheap and satisfactory way of guarding against an emergency stoppage, whether this be regarded as a final answer or as a temporary method to be adopted while more elaborate means are in course of preparation; and, as previously mentioned, the possibility of adapting standard oil-fired furnaces, of both tilting and stationary types, for the use of coke, by including a fire grate and coke charging holes, is under investigation.

In all the foregoing remarks, under headings A, B and C, it is to be presupposed that whatever type of furnace and whatever fuel may be under consideration in any given case, the installation will be carried out by a firm with experience of that type of equipment and of that particular fuel.

The Report includes an important section on relative costs.

NEWS IN BRIEF

COVENTRY MOTOR FOUNDRY COMPANY, LIMITED, is being wound up voluntarily. Mr. M. G. Dadley, 2, Queens Road, Coventry, is the liquidator.

FOR THEIR report and accounts to June 30 last the United Steel Companies, Limited, have adopted a new arrangement which has resulted in the saving of nearly a ton of paper in comparison with previous years.

MR. J. W. RAMSDEN has been appointed general manager of the Globe Steelworks of Ibbotson Bros. & Company, Limited, Sheffield. Mr. Ramsden is a director of the company and retains his seat on the board.

WHOLESALE PRICES IN SEPTEMBER, as measured by the Board of Trade index number, showed a fractional decrease (0.1 per cent.) compared with August, this being the result of divergent movements for food and industrial materials.

MINISTRY OF LABOUR returns show that the total number of persons registered as unemployed in mid-September was 104,108, against 113,825 a month before. Of the total of 104,108, 55,661 were men, 12,171 boys, 25,274 women, and 11,002 girls.

SIR ANDREW DUNCAN stated in the House of Commons that over 250,000 tons of iron railings had been consigned to the works producing iron and steel, while about 73,000 tons remained on the reserve dumps. Certain preparation had to be done upon these railings, and it was being done at the dumps.

ESTIMATED AMERICAN CONSUMPTION of iron and steel scrap in the first seven months of 1942 has totalled 32,443,000 gross tons, against 30,948,000 tons in the corresponding period of 1941 and 21,738,000 tons in the like period of 1940. The seven-month total for 1942 is greater than the scrap melted in the whole of 1939.

THE BILSTON (STAFFS) CORPORATION invites tenders by November 2 for the laying and jointing (Johnson couplings) of approximately three miles of 12-in. bitumen-lined steel pipes, together with rail and canal crossings. Further particulars may be obtained from Mr. A. V. Williams, town clerk, Town Hall, Bilston. A fee of £2, which is returnable, is charged.

THE SCHNEIDER armament works at Le Creusot, 170 miles south-east of Paris, was the main target of 94 four-engined Lancaster bombers of the R.A.F. on Saturday evening. The attack was described as the heaviest unescorted daylight attack of the war. A great weight of bombs was dropped on the factory, causing many fires, followed by a tremendous explosion.

AMERICAN FINISHED STEEL production in the first half of this year totalled 32,684,000 net tons, an increase of 5 per cent. on the parallel period of 1941, according to the American Iron and Steel Institute. Plates accounted for nearly one-sixth of the output, representing about a 90 per cent. gain over the comparable period of 1941. Sheets, strip and wire products registered declines. Tinplate production gained 17 per cent. to 1,766,000 tons.

DEATH OF DR. PERCY LONGMUIR

Dr. Percy Longmuir, the well-known metallurgist, died on Sunday last at his home in Sheffield. Dr. Longmuir, more than two decades ago, had earned an international reputation as an expert in iron and steel, particularly in foundry work, in which branch of metallurgy he commenced his professional life. Here it may be recalled that he was a founder member of the Institute of British Foundrymen, of which he was also a past-president. Early in his career he was granted a Carnegie Research Scholarship by the Iron and Steel Institute, and spent about two years in the Metallurgical Department of the University of his native Sheffield, and, later, a short period at the National Physical Laboratory at Teddington. During the war of 1914-18, Dr. Longmuir, as works manager of the Stocksbridge works of Samuel Fox & Company, Limited, rendered notable services to the nation, for which he was awarded the M.B.E. Thereafter he devoted himself almost exclusively to consulting work. Dr. Longmuir had an intimate knowledge of Continental practice, having visited many works there on numerous occasions. He was also the author of many Papers to technical societies, and made many contributions to the technical Press both in this country and America. The name of Longmuir is held in deep affection by many noted metallurgists throughout the world to-day, who acknowledge with gratitude their indebtedness to him during their student days, for Dr. Longmuir was not only an able technician, but took a deep interest in the academic guidance of the younger members of the profession, being the author of various text-books which long held a prominent place in their respective categories. His protegés will learn with regret of his passing at the age of 66.

CONTROL OF FACTORY PREMISES

Under the Location of Industry (Restriction) Order, 1941, the use to which premises of 3,000 sq. ft. in area or over are put has been subject to control by licence, the prior permission of the Regional Offices of the Control of Factory and Storage Premises being necessary before the use to which a factory or warehouse was put could be changed or any premises of 3,000 sq. ft. or over could be used for purposes of production or storage.

By a new Order (Location of Industry (Restriction) Order, 1942), which revokes the 1941 Order, a licence must now be obtained whatever the size of the premises. Goods may be temporarily stored for 28 days without a licence under the existing General Licence, which remains in force. Licences issued under the earlier Order remain valid. Again, no application for a licence need be made in order to continue to carry on business in premises which were exempt.

MR. JOHN HALL FARMER, general manager of the Central Marine Engine Works of William Gray & Company, Limited, West Hartlepool, has been appointed a Justice of the Peace.

OBITUARY

MR. JOHN MACGREGOR LAIRD, a former chairman of Cammell Laird & Company, Limited, died at Camberley, Surrey, recently.

MR. ROBERT BROWN CREAK, who for years was with the Sturtevant Engineering Company, Limited, died recently. He was in his 81st year.

SIR SAXTON WILLIAM ARMSTRONG NOBLE, BT., died at Bath on Tuesday, October 13, aged 79. He was formerly a director of the Mond Nickel Company and a managing director of Sir W. G. Armstrong, Whitworth & Company, Limited.

MR. WILLIAM ROBERT STORIE, who died recently at Denny, Stirlingshire, at the age of 63, was an agricultural implement expert. Until 10 years ago, when he took over the agricultural side of the Denny Ironworks of Cruikshank & Company, Limited, he was principal of the firm of Storie's Limited, Kelso.

MR. WALTER NORMAN SLINGSBY, commercial manager of Walter Slingsby, Limited, malleable-iron founders and tube fitting manufacturers, of Keighley, Yorks, died in hospital on October 15 as a result of injuries received when he fell from a vehicle while going on Home Guard duty. He was 36 years of age and son of the senior director in the firm.

MR. JOHN W. BURT, joint managing director of Acme Wringers, Limited, Glasgow, and one of the best known men in the ironfounding and allied metal industries in Scotland, died on October 13, after a short illness. He was the youngest son of Mr. Peter Burt, who founded the firm and is still active as its chairman. He was especially interested in design and the creation of modern plant for domestic work. He was a director of the Glasgow Chamber of Commerce, and was in 1939 appointed a member of the Committee for Art in Industry. He served in the last war in the Royal Flying Corps, on the staff of Lord Trenchard. He was 53 years of age.

UNITED STEEL COMPANIES, LIMITED

The net profit of the United Steel Companies, Limited, for the year ended June 30 last was £150,493 lower than that for the previous year. The balance of profit for the year, after making deductions for depreciation and E.P.T. and paying the interest on debentures and notes, was £1,916,132, the comparable figures for 1940/41 and 1939/40 being £2,066,625 and £2,256,078 respectively. The dividend, as previously announced, is maintained at 8 per cent.

From the net profit of £1,916,132, the directors have transferred £125,000, as before, to the central reserve for obsolescence; £1,154,000, practically the same figure as last year, goes to reserve for income tax; £152,000 (against £134,000) goes in contributions to staff and workmen's pension and life assurance schemes, and £49,153 (£47,273) is reserved for debenture stock redemption. These items total £1,480,153, and of the balance, £386,000 is absorbed by the dividend payment and the remainder is carried forward.

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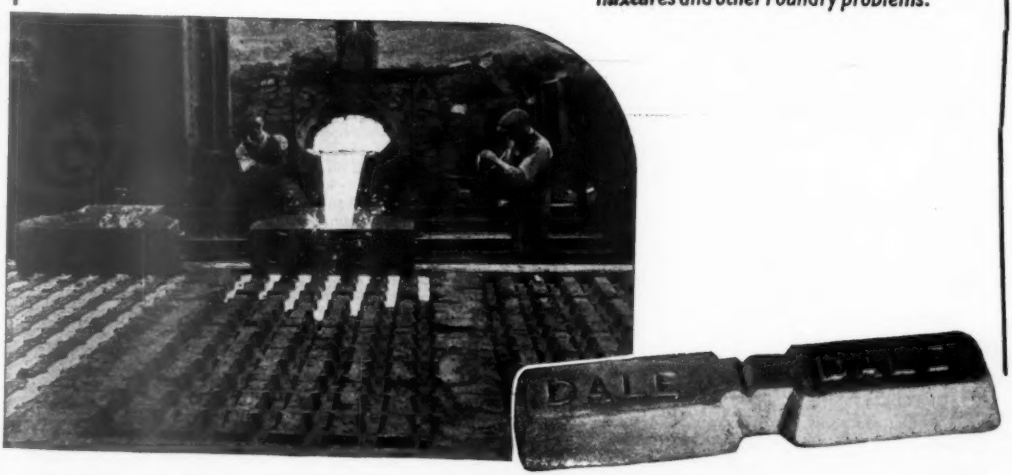
Users are invited to avail themselves of the Stanton Technical Service which offers free expert advice on special mixtures and other Foundry problems.



THE STANTON IRONWORKS COMPANY LIMITED, NEAR NOTTINGHAM

COMPANY NEWS

(Figures for previous year in brackets.)

Kitchen & Wade—Interim dividend of 12½% (same).

Cornercroft—Final dividend of 9%, making 15% (same).

Smith's Stamping Works (Coventry)—Dividend of 10% (same).

Lightalloys—Final dividend of 7½d. per 5s. share, making 1s. 3d. (same).

Metal Agencies—Interim dividend on the ordinary shares of 3¼% (same).

Thomas Blackburn & Sons—Dividend of 7½% on the ordinary shares (6%).

British Thermostat Company—Interim dividend of 7½% (same) on the ordinary shares.

Callender's Cable & Construction Company—Interim dividend on the ordinary shares of 5% (same).

Hughes-Johnson Stampings—Final dividend of 5% and a bonus of 10%, making 25% (same) for the year ended August 2.

R. & W. Hawthorn Leslie—Final dividend of 7% and a bonus of 5% on the ordinary shares, making a total of 15% (same) for the year ended June 30.

Villiers Engineering Company—Net profit for the year to July 31, £34,669 (£49,054 before a tax reserve of £12,451); dividend of 10% (7½% and a bonus of 2½%).

Allied Ironfounders (Ireland)—Profit on trading for the year ended June 30, 1942, of £1,309. Debit balance carried forward is reduced from £15,988 to £15,469.

Sheffield Forge & Rolling Mills Company—Net profit for the year to June 30, £36,488 (£33,441); to taxation reserve, £19,759; depreciation reserve, £4,000; general reserve, £5,000; dividend of 1s. per share, or 15% (same); forward, £5,852 (£4,254).

Wombwell Foundry & Engineering—Profit for the year ended July 31, 1942, £12,716 (£12,477); depreciation, £2,000; taxation, £6,023; net balance, £4,693 (£6,011); to general reserve, £500; dividend of 12½% (same), £4,062; forward, £5,438 (£5,308).

Oxley Engineering—Trading profit for the year to June 30 last, £76,102 (£71,822); net profit, £14,034 (£13,953); to general reserve, £4,000 (£3,000); provision for future taxation, £4,000 (£3,000 to contingency fund); dividend of 12½%; forward, £6,809 (£7,025).

Cowans, Sheldon & Company—Profit for the year ended June 30, after providing for depreciation and taxation, war risks and war damage insurance liabilities, £18,063 (£17,441); dividend of 10% (same), £15,000; to general reserve, £2,500; forward, £54,700 (£54,137).

Cochran & Company, Annan—Trading profit for the year to June 30, £82,495 (£72,065); net profit, £46,298 (£41,994); to taxation, £36,954 (£33,712); War Damage Act payments, £1,601 (£900); A.R.P., £1,717 (£1,324); final dividend of 2½%, making 4% (same), free of tax; forward, £877 (£851).

Bell Bros. (Manchester 1937)—Trading profit for the twelve months ended March 31, £11,914 (£10,980); depreciation and reserve for taxation, etc., £3,711; net profit, £8,203 (£6,221); dividend on the preference shares in respect of the year ended March 31, 1937, £7,500; forward, £6,891 (£6,187).

NEW COMPANIES

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Hall Bros. (Engineers), 11, Church Street, Drypool, Hull—£500.

Adamant Precision Tools, 104, High Holborn, London, W.C.—£1,000. H. Clayton.

Coventry Foundry, 9-11, High Street, Coventry—£7,000. G. V. Keeling and F. B. Levetus.

Taylor's (Croydon), 23-25, George Street, Croydon—Engineers, etc. £1,000. L. J. Taylor and R. A. Earl.

Hayes & Bishop—Engineers. £1,500. F. Bishop, R. S. Hayes, and P. J. Godbolt, 22, Hereward Avenue, Purley, Surrey.

Liddiard & Lloyd, 598, High Road, Chiswick, London, W.4—Founders, metal workers, etc. £500. F. R. Lloyd, C. A. Liddiard, and V. Cain.

Carbonit, 239, High Street, Hounslow, Middlesex—Metal merchants, treaters and hardeners, engineers, etc. £100. E. G. Seeley and F. R. James.

W. Elliott & Son (Welson)—To take over an engineering business carried on at 303, Mount Road, Levenshulme, by H. A. Elliott. £5,000. H. A. and E. Elliott.

Industrial Supplies Company (Midland)—Agents for and dealers in pumps, machinery, tools, etc. £1,000. J. Bell, Stratford Lodge, Station Road, Wylde Green, Warwick; W. K. Bird, and C. Pullan.

Stewart & Gray—To amalgamate the businesses of porcelain enamel manufacturers, general enamellers, etc., carried on formerly by J. F. Stewart & Company, Limited, and J. Gray & Sons, Limited. £50,000. W. Thomason, Windleshaw, Nelson Road, New Malden; J. W. G. Pedder, R. J. Thomason, N. F. Parker, and J. T. Gray.

NEW PATENTS

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each.

547,647 SPENCER, H. W. (Bigelow, F. B.). Furnace walls.

547,684 BRITISH OVERSEAS AIRWAYS CORPORATION, and SAUNDERS, F. S. Machine for bending any pre-formed metal shape along its longitudinal or transverse axis.

547,689 KEENER, S. F., and HOPKINS, J. H. Method and apparatus for heating ingots and the like.

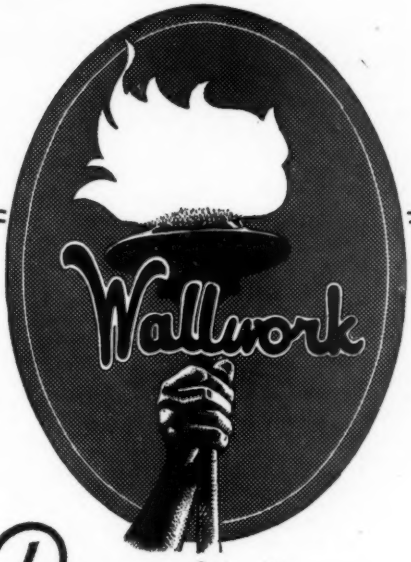
547,700 ELECTRO METALLURGICAL COMPANY. Method of producing cast iron, and compositions therefor.

547,708 ELECTRO METALLURGICAL COMPANY. Method of producing cast iron, and compositions therefor.

547,714 ARMOUR, A. M., and METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED. Detection of variation in wall thickness of tubes of magnetic material.

547,721 REES, J. G. Ingot mould-making machine.

547,799 VANDERVELL PRODUCTS, LIMITED, TEMPLE, C. F., and GREEN, D. F. Surface treatment of composite metal bearings or bearing surfaces.



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Raw Material Markets

IRON AND STEEL

Generally speaking, pig-iron consumers are well placed with regard to supplies and many have quite considerable tonnages in stock. This applies particularly to high-phosphorus iron, which is produced from ores found in the United Kingdom. Consumption of this type of iron has expanded very considerably of late, as it is used in place of grades of better quality which are manufactured from imported ores. For example, hematite and low-phosphorus irons and other good-quality irons are not distributed by the Control authorities in cases where common foundry or high-phosphorus iron would fulfil the requirements satisfactorily.

In the heavy engineering section, works continue to be employed to capacity, and the foundries are turning out large outputs to meet the various needs of the Government departments. Activity in the light-castings trade remains subdued and not until after the cessation of hostilities will this section return to anything approaching normal conditions, as only a comparatively small proportion of its capacity is needed to satisfy war requirements, and it is not possible to permit the surplus capacity to be used for the production of castings for the ordinary domestic trade. The building industry was formerly the chief consumer of light castings, but now, despite considerable orders from Government departments, demand from this section has fallen away to an appreciable extent.

The foundry coke position may be considered to be eminently satisfactory, as many users have stocked to the limit of their accommodation, while regular deliveries continue to arrive week by week. For delivery to Birmingham and Black Country stations, the controlled minimum price of Durham best foundry coke is 69s. 3d. per ton. All contracts are subject to a rise-and-fall clause, so that both buyer and seller are covered against any change which may be made in the quotation.

The steel industry has been called upon to meet much-increased demands since the importation of American steel was brought down to a very small tonnage, and that it has been able to fulfil its commitments so well must be a source of gratification to the industry. Alloy, high-carbon and all special grades of steel are fully absorbed by armament makers, aircraft works, etc., and the demand is tending to expand. In other directions, the demand for steel plates is very large, especially from the shipyards, while big quantities are also required by the structural engineers, boiler and tank makers, etc. Pressure for structural steel of various types is extensive, while the sheet trade is operating to capacity. Demand for sheets has increased of late and there is no longer any large quantity of defective sheets available for distribution, as was the case earlier in the year. The use of defectives has been a source of relief to the producers of primes. Cold-rolled strip, special quality sheets and bright-drawn steel bars are all fully absorbed on Government account.

NON-FERROUS METALS

Consumption of raw copper among undertakings employed on Government contracts is maintained at peak levels, and it appears that adequate supplies are being delivered, although no more than is absolutely essential to satisfy really urgent needs. The Control authorities will not permit extravagant usage of the red metal, and ordinary domestic consumers' allocations are strictly curtailed. Brassmakers, electrical goods manufacturers, etc., are the chief users of copper, having extensive orders on hand for the various Government departments.

Shortage of labour is affecting domestic output of copper in the United States. Mineowners have informed the War Production Board that the domestic output during the month of July last was some 5,000 tons less than it might have been had the supply of labour been sufficient to man the mines fully. The American authorities are endeavouring to curtail the consumption of copper, and a number of prohibitions have been made. An announcement by the War Department states that in the ordinary way 70,000 short tons of copper would be required for building purposes in a construction programme of the size and scope of that now being undertaken by the Army, but owing to the tightness in copper supplies actual consumption will be kept down to about one-quarter of this amount.

Experts both in this country and in the United States are engaged upon methods for restricting the consumption of tin, as supplies available to the United Nations have been appreciably reduced by the Japanese occupation of tinfields in the Far East. Production of tin also is being investigated with a view to expansion, but it is realised that it will not be possible to make up for the losses sustained in the East.

Munitions works are utilising substantial quantities of spelter, and allocations to galvanisers have been brought down to a very low level compared with the supplies which were sent to these users earlier in the war.

STEELMAKERS' PROFITS

Mr. W. W. Wood, on his installation for the third year in succession as Master of the Cutlers' Company, Sheffield, said that some people had suggested that the steel trade was making enormous profits. If they thought a little more about it, they would understand that most selling prices were fixed and had been for years, and that all the time the manufacturer was having to produce against rising costs of wages, coal, timber, and a host of other commodities, which had risen to such an extent that a compensation fund had had to be formed to be drawn upon when profits fell below 25 per cent. of the pre-war average of the years 1936-1937. Before people spoke about enormous profits, they might well endeavour to find out how many steelmakers had been compelled to apply to this fund. Some makers had little more than the satisfaction of feeling that they were contributing to a policy of non-inflation.

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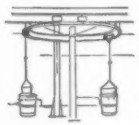

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